TOXIC WASTE: DARKENING CLOUD OVER U.S. BUSINESS

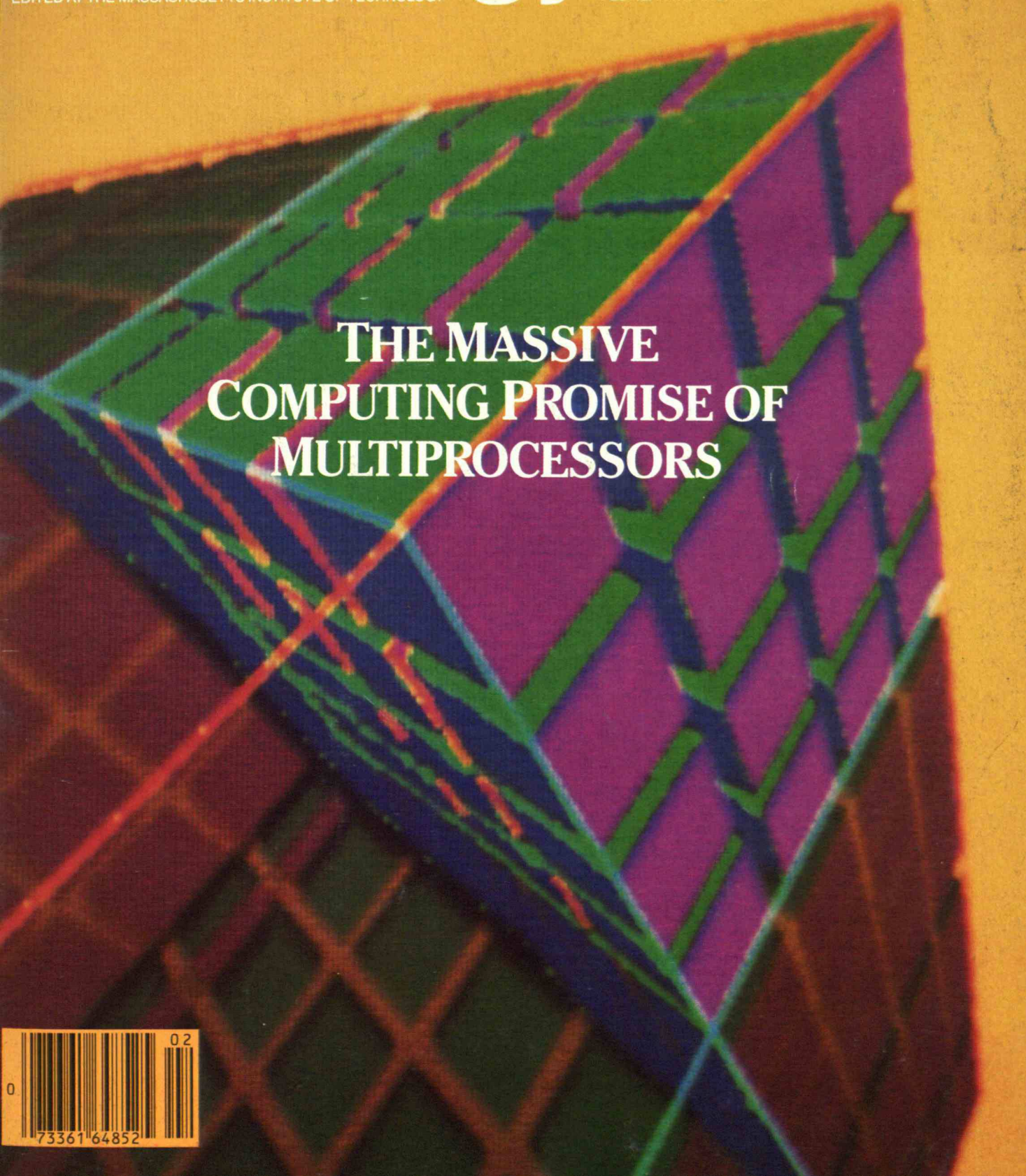
DO PATENTS CORRUPT UNIVERSITIES?

Technology Review

EDITED AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

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THE MASSIVE COMPUTING PROMISE OF MULTIPROCESSORS

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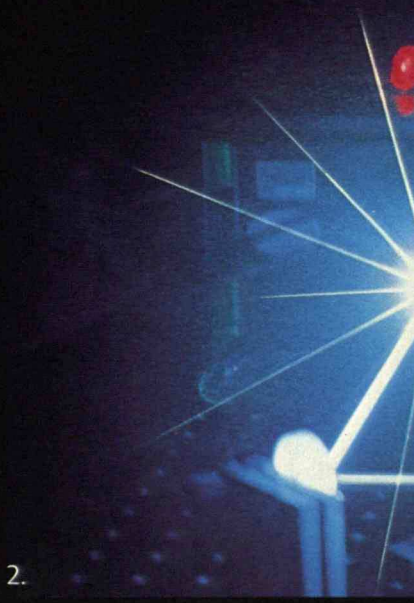
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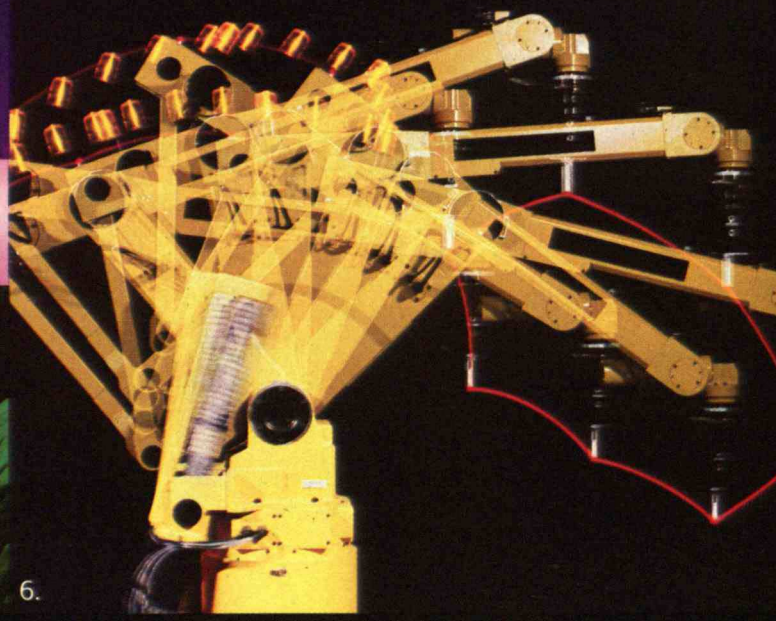

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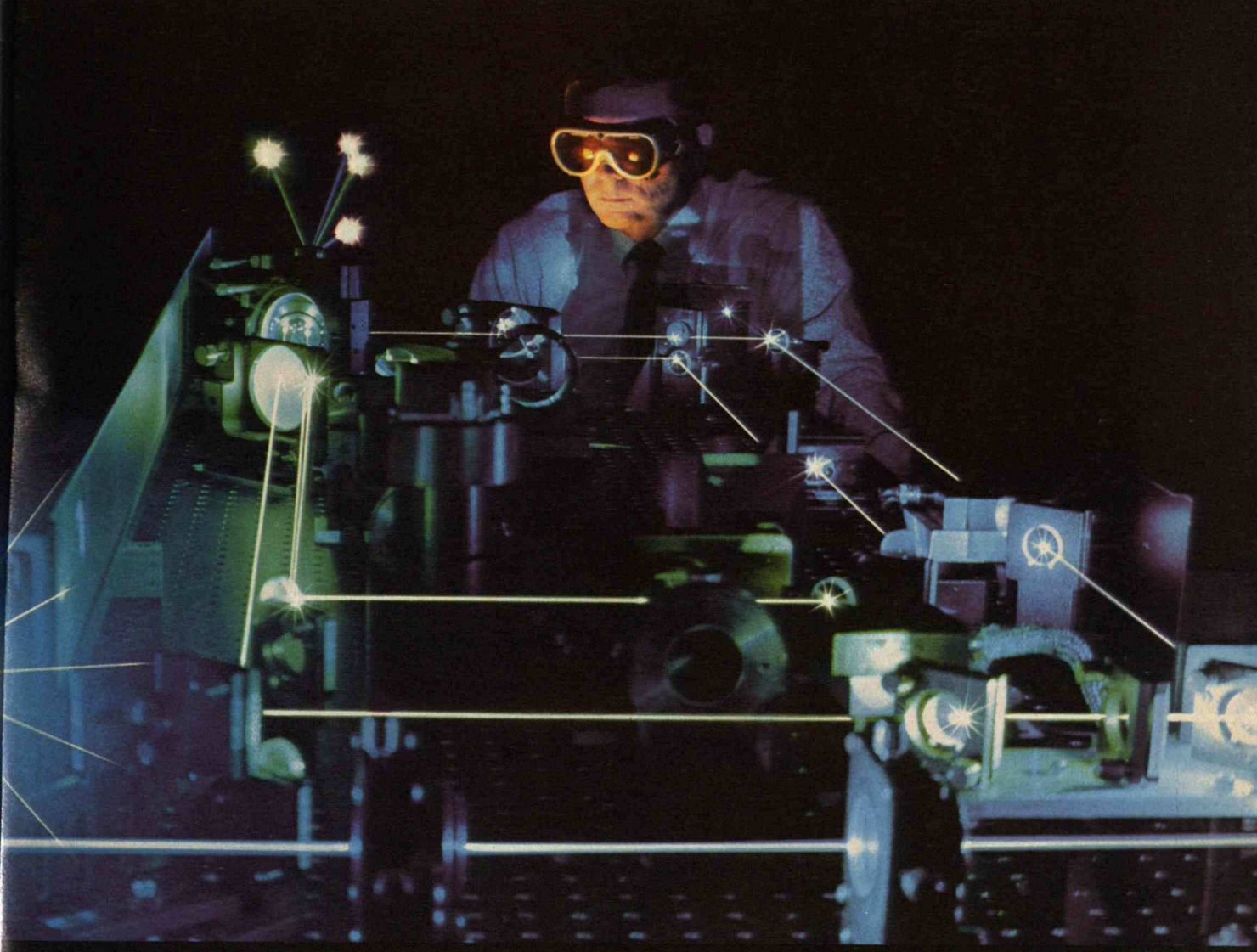
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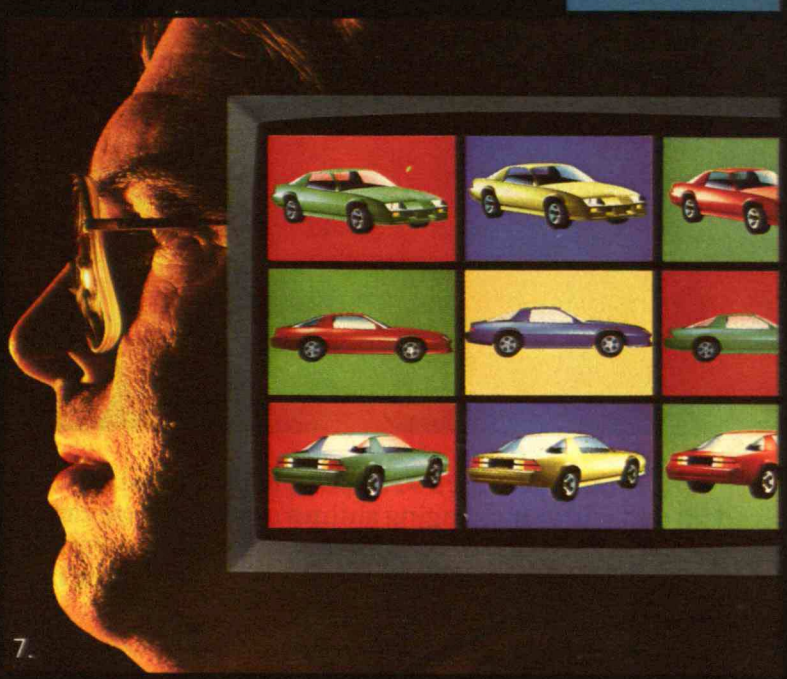

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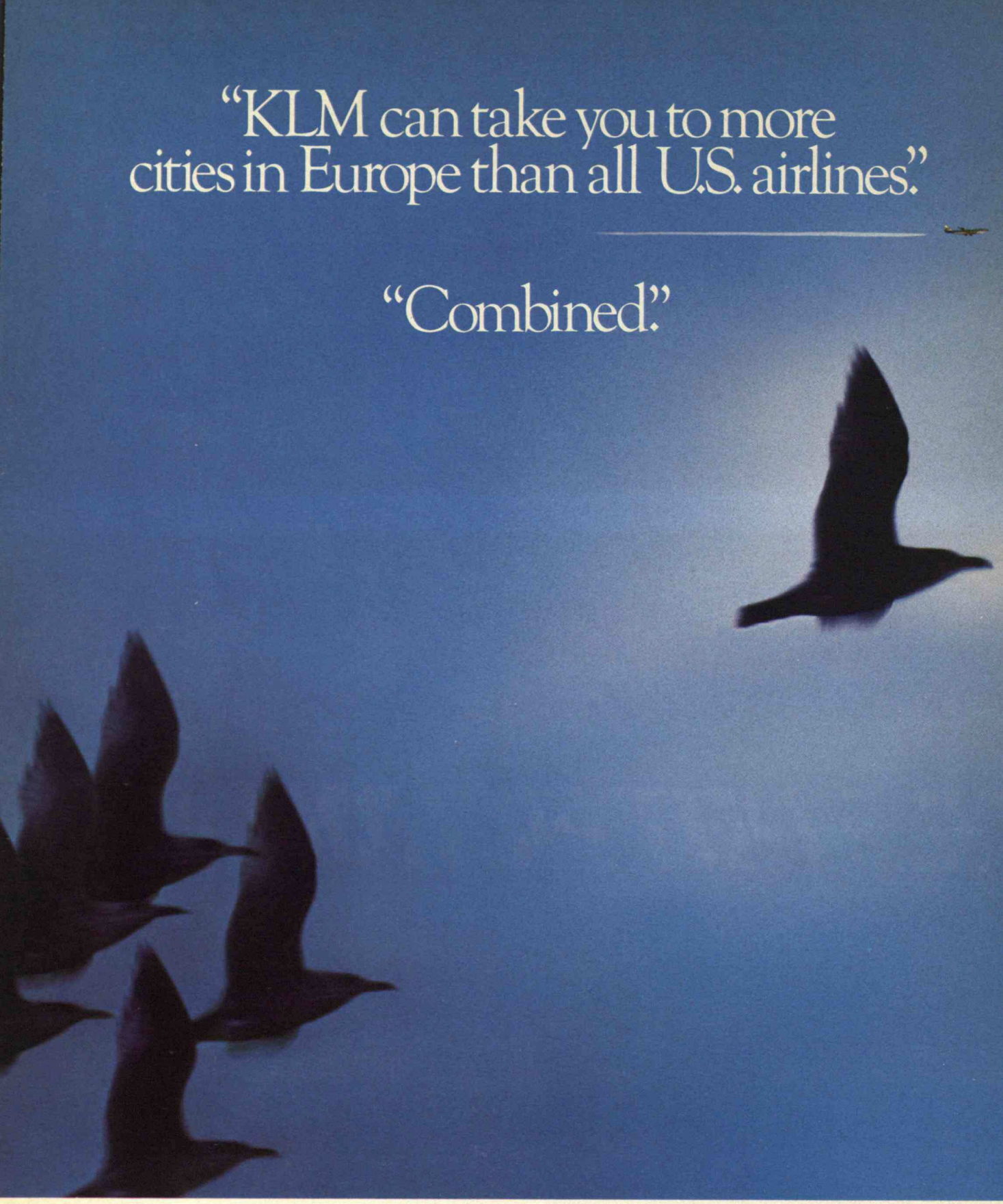
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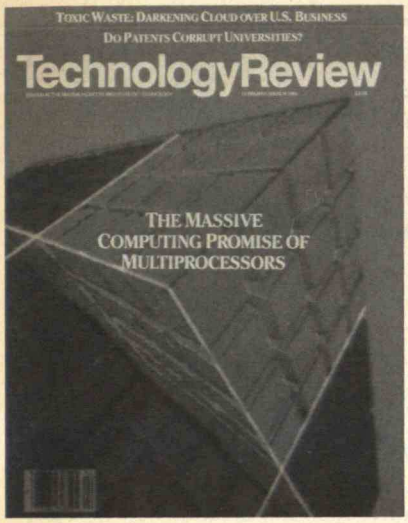
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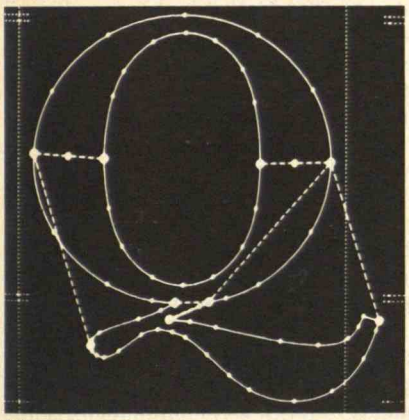
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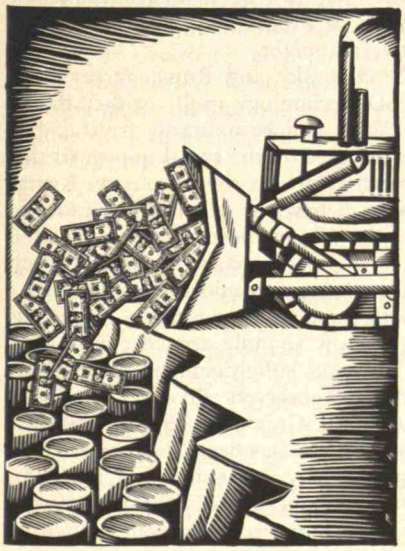
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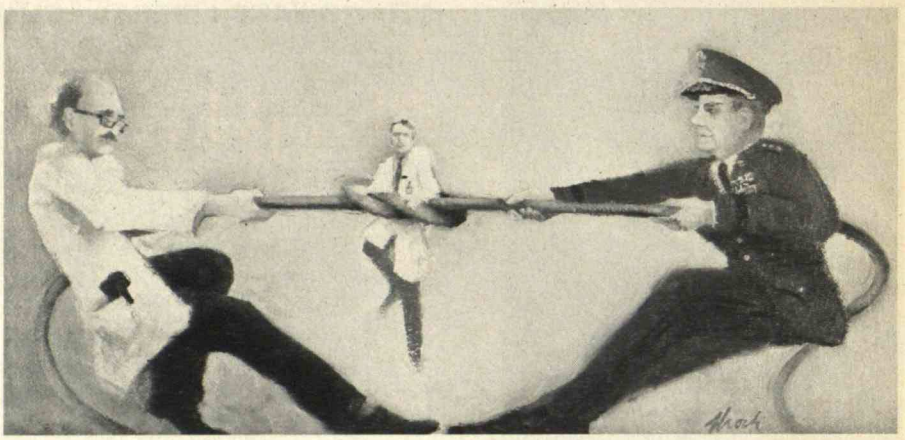
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Learning from Controversy



We too often think of engineering as a profession that exploits predictable materials and mechanics and so deals little if at all with ambiguity and uncertainty. Indeed, many engineers cherish such an understandable, apparently infallible world.

But engineering is not so simple. As their projects become more complex, engineers are realizing that they can only hypothesize about the behavior of interlocking systems. The effects of new technology and especially of new systems simply cannot be foreseen when they are in their first, most primitive forms. And questions about social impact bring ambiguity to most engineering decisions.

This and the preceding issue of *Technology Review* clearly demonstrate the uncertainties in complex systems and in the interface between society and technology. In our cover story in January, Professors Hubert and Stuart Dreyfus wrote that "artificial intelligence has failed to live up to its promise, and there is no evidence that it ever will." But in this issue Professor Michael Dertouzos argues that multiprocessors—devices with which the Dreyfus brothers are thoroughly familiar—may enable us to realize "some of our most romantic and ambitious aspirations" for computers—machines that will "recognize images, understand speech, and behave more intelligently."

Also in our January issue, Professor Vera Kistiakowsky argued that university communities should eschew research related to the Reagan administration's Strategic Defense Initiative—the controversial Star Wars program. In this issue Professor Jack Ruina argues with equal fervor *against* eliminating SDI-related research from the academic environment.

Some of the differences in these points of view are more apparent than real. The Dreyfus brothers, for example, argued that it is futile to seek "thinking machines" that will emulate the human mind because the mind often responds intuitively rather than following cookbook rules; it often relies on holistic recognition of images rather than sequential logic; and it brings a world of experience to bear on even the simplest daily decisions. Who can conceive of machines that can do these things?

Dertouzos acknowledges many of these points. "Consider the cerebellum, where over a trillion cells share the complex task of higher-level thinking in yet unknown ways," he writes. "What arrogant reasoning led us to believe that a single processor capable of only a few million instructions per second could ever exhibit intelligence?" But he believes that thousands or millions of processors, working concurrently, just *might*.

Kistiakowsky and Ruina agree about the SDI technology itself; neither thinks Star Wars will be militarily fruitful. But they disagree on the social impact of this research effort on the university. Kistiakowsky believes it will distort academic priorities; Ruina believes that concerted faculty opposition to any arena of research will itself impair academic freedom.

Both these issues, we think, are examples of how soundly argued controversy can provide enlightenment for participants and observers alike. M.I.T. President Paul E. Gray notes that the national debate on SDI has been "invigorated and illuminated by discussion and reflection within the universities." That spirit of constructive controversy motivates much of what appears in our pages, too.

—John Mattill

Asteroids, Computerized Walking

ASTEROIDS AND NUCLEAR WAR

In "The Bombarded Earth" (*July, page 64*), Eugene F. Mallove says that asteroid bombardment differs from nuclear warfare largely because the former is inevitable. Based on just this one criterion, asteroids win 1-0 as the bigger threat. Popular conclusion: forget nuclear war.

In fact, I estimate that the odds of nuclear war are more than 1 percent per year, while the likelihood that an asteroid will collide with the Earth and do equal damage is about 1 percent per hundred years. Moreover, nuclear war entails dangers the public has not been encouraged to appreciate. For example, the press compared the eruption of Mount St. Helens with the "equivalent" explosion of H-bombs, disregarding the insidious nature of lethal fallout.

On a more cheerful note, writers of sci-fi stories and comic strips have speculated that the United States and the Soviet Union might use their large missiles *cooperatively* to eliminate dangerous asteroids. Defending ourselves against an asteroid is no doubt several orders of magnitude easier than defending against a full-scale nuclear attack, and if it requires most of the 15,000 or so warheads of both sides, so much the better. Having at last learned the benefits of U.S.-Soviet cooperation, we could simply destroy the rest of the weapons—or, better still, dilute their highly enriched fissile material for use as fuel in nuclear power plants. (This would allow us to produce 5 trillion kilowatts of power, or several hundred billion dollars' worth of electricity, according to a detailed proposal by Westinghouse.)

Hoping for an asteroid to save us from ourselves seems crazy, but it may not be in this crazy world.

ALAN F. KAY
Winchester, Mass.

The author responds:

I don't believe my article could lead most people to conclude that asteroids are more dangerous and important than nuclear war. Nor do I agree that press coverage of the Mount St. Helens eruption may have lulled the public into a false sense of security. The public, I think, instinctively knows about the hazards of radioactive fallout, even if it doesn't know the details.

Also, it is not true that the chance that an asteroid impact will create damage equal to that from nuclear war is 1 percent per hundred years. According to the numbers I have seen, it is likely to be far less than that. In any case, direct comparison of nuclear war and asteroid impact is difficult at best. My point is that *both* nuclear war and asteroid impact are serious hazards. Society needs to attend to both of them, though it is obviously much more urgent to prevent nuclear war. Yet we can't ignore Eugene Shoemaker's claim that there is a 40 percent chance that another Tunguska-like event will occur within the next 75 years. A lot of people may be hit—and soon!

One more point: we don't need nuclear weapons to deflect an asteroid if its trajectory is known early enough—say 10 to 15 years before impact. Conventional explosives or rockets will suffice. Also, I'm sure that some eager military strategists have noticed how convenient it would be to have a properly sized cosmic chunk come down on Moscow or Washington. Fortunately, it would be difficult to sneak away from Earth unnoticed to divert an asteroid to do just that.

USING ELECTRONICS TO HELP PEOPLE WALK

Four years ago, most people considered computerized walking "impossible," even though, as Michael J. Rosen admits, it had been going on in the laboratory for a long time. (*See "The Nan Davis Story: A Trail of False Hopes," July, page 60.*) Ironically, there wasn't much concern about correcting the public's misimpressions about the progress of such research until the public became hopeful.

Researchers say they are worried about false claims. But I suspect their real fear is that the public might begin to ask what other "impossibilities" have been possible all along. Embarrassing questions are already surfacing about why tax dollars spent on research aren't producing much for human benefit besides employment for scientists.

Also, if, as Rosen suggests, Jerrold Petrofsky cultivated the media, he probably did so to garner more funding. Many of Petrofsky's critics might secretly regret not having come up with the idea themselves.

ADELE TANNER
Amherst, Mass.

Adele Tanner is president of the western Massachusetts chapter of the Spinal Cord Society.

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ROBERT C. COWEN

Time for Chemists to Pull Their Heads from the Sand

THE chemists of the United States have peered into a (synthetic) crystal ball and glimpsed a bright future. Give them more money and tools for basic research and they promise to produce more food, better medicines, cleaner environments, and wondrous new materials. A National Academy of Sciences (NAS) report, commissioned to take a comprehensive look at the state of U.S. chemistry for the first time in 25 years, spells all this out in detail. Editorializing in *Science*, E.G. Jefferson, chairman of the board of Du Pont, calls the report "an impressive 350-page catalog of gifts to society that the chemical sciences can provide if we will just fill out our national order blank."

I wonder if the public sees it that way.

While *Science* ran Jefferson's editorial under the headline "America's Ultimate Christmas Catalog," today's newspaper headlines reflect a very different perception of chemistry's role in society. "Problems at Chemical Plants Raise Broad Safety Concerns," proclaimed one. "U.S. Names 403 Toxic Chemicals That Pose Risk in Plant Accidents," another warned. A third headline reported that "Labels on Household Products Begin to Warn of Long-Term Health Threats." And recently, the American Chemical Society's weekly *Chemical & Engineering News* (*C&EN*) reported on an Environmental Protection Agency study that found that nearly 7,000 accidents involving toxic chemicals had killed 139 people and injured 1,478 over the preceding five years.

Chemists bearing gifts aren't exactly welcome in American society these days. Yet you would scarcely realize it in thumbing through the NAS report, *Opportunities in Chemistry*. Nor would you realize the depth of public concern by the attendance at the ethics session sponsored by the American Chemical Society's Women Chemists Committee during the ACS national meeting last September in Chicago.

Certainly the NAS study, led by George C. Pimental of University of California at Berkeley, is justified in the scientific promises it makes. These promises are based on detailed examination of the chemical sciences, which encompass chemical engineering, material sciences, and many aspects of biology and environmental science. U.S. policymakers generally should heed the study's advice that we beef up funding for research in these fields, especially at universities, to maintain leadership in the chemical sciences. We all can appreciate the study's point that the chemical industry—which ultimately depends on basic research—is a vital national resource, as it annually runs a $12 billion positive international balance of trade.



If chemists ignore safety concerns, the chemical industry may become as hamstrung as nuclear power.

The Public's Overriding Fear

However, the single overriding public concern regarding chemistry is safety and fear of being poisoned. This is where the Pimental report appears naive and somewhat confused about the public's priorities. It asserts that to understand and solve environmental problems involving chemicals, "our society must assure the health of its chemistry enterprise." The report reflects an implicit assumption that, if only American society can be made to realize the benefits chemistry has to offer, the public will automatically boost its support of the field.

The report also implies that while chemists have a responsibility to deal with issues of public concern, this responsibility is less important than their responsibility to perform scientific research. In a one-paragraph comment, it notes that the public is involved in choosing and implementing policies dealing with environmental risk and observes that "chemists . . . have a secondary, but important, informational responsibility here." The report makes no mention of the moral and ethical responsibilities of individual scientists, despite increasing public concern about such matters.

Louis Fernandez, chairman of Monsanto and immediate past chairman of the Chemical Manufacturers Association, seems to recognize this fact: "The big issue for the chemical industry is to gain public confidence that it is acting responsibly and that it isn't putting dollars and profit ahead of everything else, which is a common perception."

If chemists do not effectively deal with the public's concern about the safety of their products, both chemical research and the chemical industry may become as hamstrung as the nuclear power industry. As Fernandez and other perceptive industry leaders realize, this danger supersedes all other issues in the field today. Yet insensitivity to the magnitude of the problem seems to be widespread among chemists.

For example, the introduction to the NAS report justifiably proclaims that "there is no area of basic science that offers a more secure investment in the nation's future." It finds chemistry's progress to be "epitomized by the striking fact that the number of new compounds continues to increase at a rate faster than exponential." Yet many people are alarmed by that very fact; they wonder what new chemical horrors are being released daily into the environment.

Moreover, the Pimental report expects a deficit-conscious Congress and administration to let the National Science Foundation "begin a three-year initiative to increase its support for chemistry by 25 percent a year," beginning in fiscal year 1987. The current level of support is about $150 million. The report also urges the

Continued on page 14



ROBERT C. COWEN IS SCIENCE EDITOR OF THE CHRISTIAN SCIENCE MONITOR AND FORMER PRESIDENT OF THE NATIONAL ASSOCIATION OF SCIENCE WRITERS.

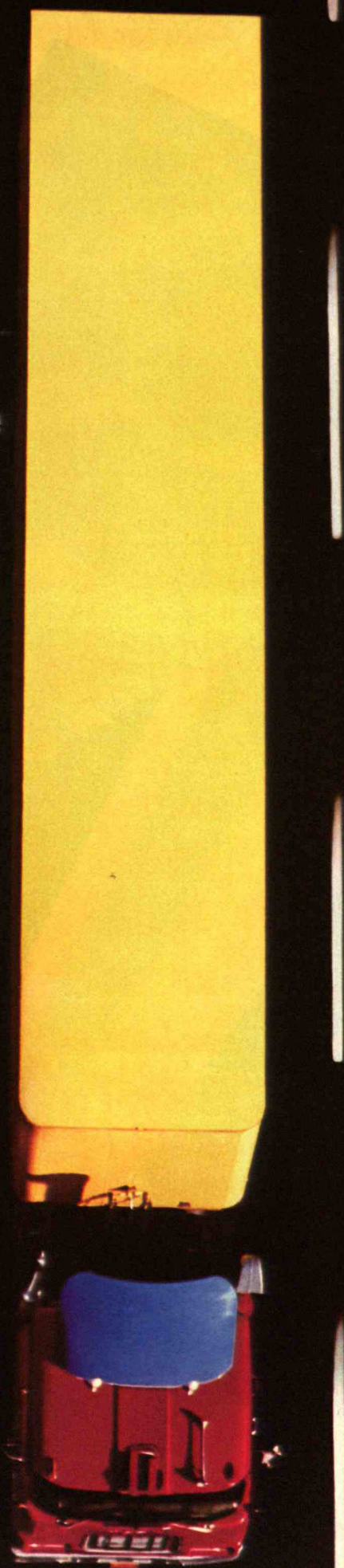
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It's time for a new perspective on trucking.

Chances are, you never thought of a truck driver as a professional who manages his business as skillfully as he maneuvers his vehicle. Or that the trucking industry depends on safety to stay in business.

Maybe you never realized that a professional truck driver logs more miles in a few years than the average motorist drives in a lifetime. Or that the likelihood of a tractor-trailer being involved in an accident is about half that of a car.

Perhaps you didn't know that a professional truck driver checks three dozen separate items on his vehicle before he starts a trip. Or that he must pass regular physical exams and keep meticulous records of every mile he drives.



If you weren't aware that the industry responsible for delivering three-fourths of America's goods is so dedicated to safety, then it's time you took another look at trucking.

There's more to it than most people ever see.

AMERICA'S ROADTEAM

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THE SKY WAS THE LIMIT.

AT&T has shattered the information barrier—with a beam of light.

Recently, AT&T Bell Laboratories set the world record for transmission capacity of a lightwave communications system—20 billion pulses of light per second. The equivalent of 300,000 conversations, sent 42 miles, on a hair-thin fiber of super-transparent glass. But that's really getting ahead of the story.

Actually, the 20-gigabit record is only one of a series of AT&T achievements in the technology of lightwave communications.

But what does that record mean?

The Light Solution To A Heavy Problem

All of us face a major problem in this Information Age: too much data and too little information. The 20-gigabit lightwave record means AT&T is helping to solve the problem.

For data to become useful information, it must first be quickly, accurately and securely moved to a data transformer—a computer, for instance. Getting there, however, hasn't always been half the fun.

Metallic pathways have a limited transmission speed, sensitivity to electrical interference and potential for interception—factors that reduce the effectiveness of today's powerful computers. Factors that are eliminated by lightwave communications technology.

Ten Goes Into One 20 Billion Times

Three primary components make up any lightwave communications system. On the transmitting end, a laser or light-emitting diode; on the receiving end, a highly sensitive photodetector; and in the middle, super-transparent glass fibers we call lightguides.

Installing these fibers is a major cost of a lightwave communications system. So, once installed they should stay put—increased capacity should come from fibers carrying more, rather than from more fibers.

Which brings us to the 20-billion bit-per-second story—about experimental technology that has the potential to upgrade installed fiber to meet any foreseeable capacity needs.

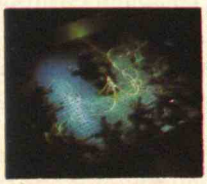
Using new, sophisticated lightwave system components, we multiplexed (combined) the outputs from 10 slightly different colored 2-billion bit-per-second laser beams into a single 20-billion bit-per-second data stream.

Playing Both Ends Against The Middle

But, let's start at the beginning—the 10 distributed feedback laser transmitters.

These powerful semiconductor lasers can be grown to produce light of different, but very precise, wavelengths. The lasers we used transmitted in the 1.55 micron (infrared) range, with only minuscule fractions of a micron between their wavelengths. The purity and stability of the beams let us pack their ten colors into the most efficient transmitting region of our single-mode, silica-core fiber.

To make the original 10 beams into one, a fiber from each laser was fed into a new lightwave multiplexer—a prism-like grating that exactly aimed each beam into the single transmission fiber. Over 42 miles later, a second grating fanned the beam back into its original 10 colors for delivery to 10 exceptionally sensitive avalanche photodetectors—receivers that convert the light pulses back into electrical signals and amplify them many times.



20-gigabit multiplexer

A similar avalanche photodetector was the receiver when AT&T Bell Laboratories set the world record for unboosted lightwave transmission—125 miles at 420 million bits per second.

From Sea To Shining Sea

System capacity is important. But system reliability is vital. Especially when the system is going under 10 thousand miles of water—and is expected to last for 25 years.

AT&T is going to build the first lightwave communications system under the Atlantic Ocean. A similar system is planned for the Pacific. In 1988, laser beams traveling through two pairs of glass fibers will carry the equivalent of 37,800 simultaneous conversations overseas, underwater, from the U.S. to Europe and the Far East.

AT&T has manufactured and installed lightwave systems—as large as the 780-mile Northeast Corridor and as small as single-office local area networks—containing enough fiber to stretch to the moon and back. And the capacity of each network is tailored to meet the unique needs of its users.

Systems being installed in 1985 will be able to grow from 6,000 up to 24,000 simultaneous conversations on a single pair of fibers.

AT&T is meeting today's needs with lightwave systems that are growable, flexible and ultra-reliable. And anticipating tomorrow's needs with a whole spectrum of leading-edge lightwave communications technologies.

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LESTER C. THUROW

The Economic Case Against Star Wars

ADVOCATES and critics of President Reagan's Strategic Defense Initiative (SDI) have hotly debated the program's technical feasibility as well as its strategic and political implications. But what about SDI's effect on the U.S. economy? Some say the high-tech spinoffs from SDI research and development will revitalize the civilian economy. Others say that SDI will drain the civilian economy of money and skilled labor that the United States needs to compete in world markets.

In discussing the economic impact of Star Wars, we should keep in mind a few basic "rules of thumb" about military spending. The first rule is that no defense spending can be justified on economic grounds. Anyone familiar with Japan's economy can see that defense spending is not at all necessary to make a civilian economy work.

Military spending has to be justified on military grounds. Efforts can be made to minimize the economic drawbacks of such spending and maximize the spinoffs for the civilian economy. But if creating civilian technology is the end goal, then it is best done through civilian research and development. The issue is much like studying Latin to help's one English. Those who know Latin know something that helps their English, but if the aim is to learn English, one can most efficiently spend one's time studying English.

Second, defense is a form of public consumption. If Americans want to have more defense consumption, they have to be willing either to cut other forms of public consumption or to raise taxes. The current military buildup is a drain on the future productivity of the American economy since it is being paid for with deficit spending. Defense is financed with funds borrowed from the pool of savings that would otherwise be available for capital investment to enhance future productivity. As a result, there are fewer funds available for investments in plant facilities and equipment and in human skills—investments that could raise the productive capacity of U.S. industry in the future.

The third rule is that defense spending diverts scarce engineering and scientific talent from civilian to military activities. The severity of this diversion depends on how much of the total supply of talent is being diverted and what is being done to augment that supply. Previous military and space buildups have always included funds for increasing the supply of engineering and scientific talent. For instance, the space efforts of the 1960s included the National Defense Education Act, designed to train more engineers and scientists. There is no equivalent for SDI.



Battered by deficits, the civilian economy could use the talent and money now lavished on Star Wars.

Without such educational programs, huge increases in military spending inevitably drain engineering and scientific talent away from civilian industries. About 40 percent of America's scientific personnel now work in defense-related efforts, and a major buildup would divert even more talent from the civilian economy.

The United States now has economic competitors who are its technological equals. When our nation had a technological edge over its international competition, it could be somewhat relaxed about diverting investment funds and scarce talent to military efforts. We cannot afford that attitude today. Whatever the need for tax increases and education was in the past, it is even greater today.

The fourth point—and perhaps the most surprising—is that civilian spinoffs from military spending have become harder and harder to find as defense moves into space. The requirements for operating in space are very different from those on earth. Extreme lightness, miniaturization, and reliability are of much less value on earth than in space.

We can find many examples of civilian spinoffs from the military in the distant past—the Boeing commercial jet airliner, for instance. But there are few in the recent past. In fact, the major inventions of the past few decades have spun off from the civilian economy to the military. The transistor was invented by AT&T. Semiconductor chips were developed by an oil-well instrument company—Texas Instruments—and personal computers were developed by hackers. Perhaps Star Wars will develop something of great value to the civilian economy, but recent history provides no reason to be optimistic.

A fifth point is that military spending today is unlikely to spawn the economies of scale and advances in process technology that it did in the 1940s and 1950s. Then, military procurement often led to massive production runs of vehicles and aircraft. Today when the U.S. military builds 30 custom-made B-1 bombers, it operates what is essentially a handicraft industry. And that industry has little interest in building up the process technologies and economies of scale that could be useful to civilian production—those that are in fact essential to our ability to compete in international markets. Indeed, many U.S. firms rigidly separate their military production from their civilian production so that the civilian side won't be corrupted by the cost-plus, custom-made ambiance of military production.

Who Will Bankrupt Whom?

The sixth rule is that comparisons of the level of defense spending among different countries are useless. Pay no attention to those who argue for larger U.S. defense budgets on the grounds that the Soviets are spending more. U.S. defense spending should be justified by Soviet equipment and threats and not by Soviet spending.

Continued on page 15

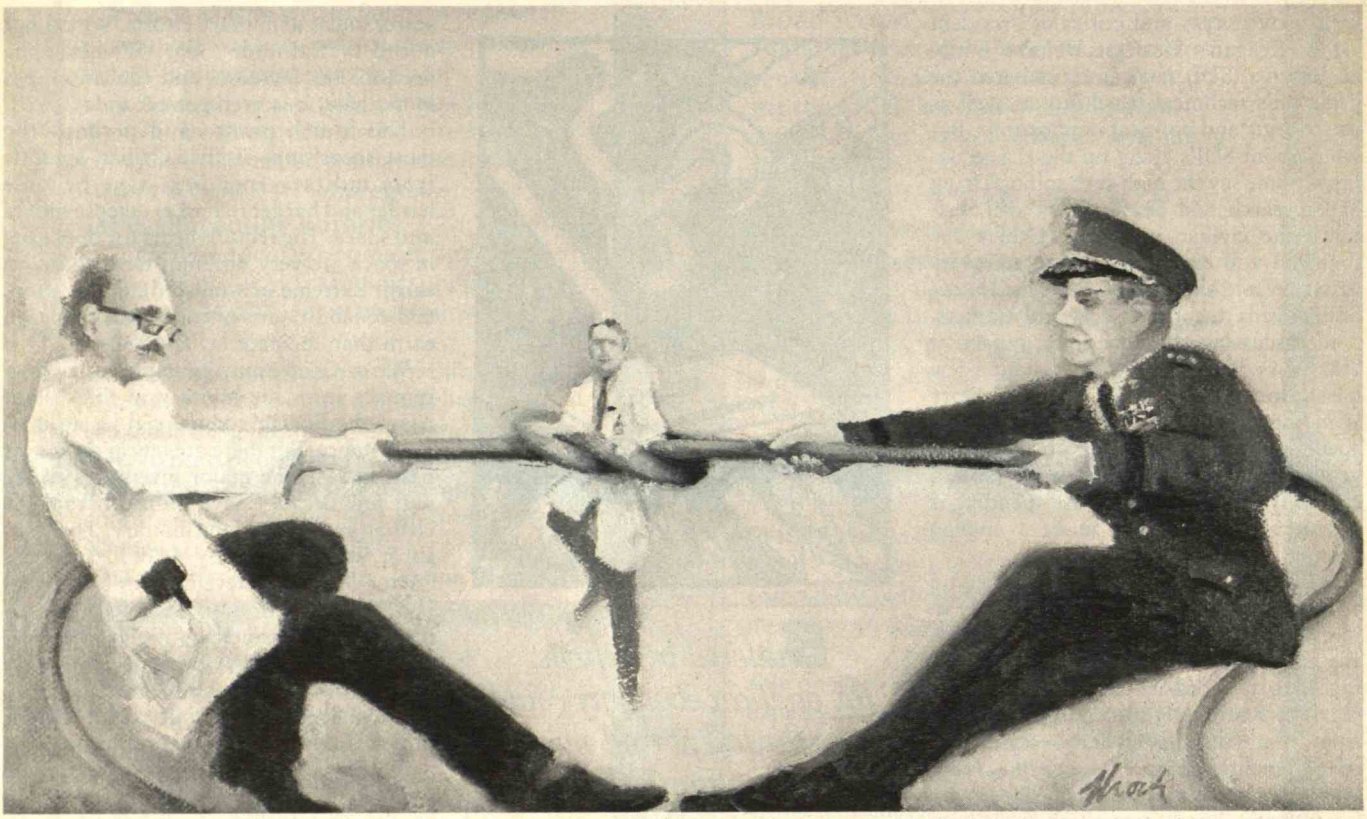


LESTER C. THUROW IS GORDON Y BILLIARD PROFESSOR OF MANAGEMENT AND ECONOMICS AT THE SLOAN SCHOOL OF MANAGEMENT AT M.I.T.

ILLUSTRATION: LESTER KANTUREK

BY JACK RUINA

SDI: Peer Pressure and Politics on Campus



THE controversy generated by the Strategic Defense Initiative (SDI) has quite naturally spilled over to university campuses. SDI-sponsored research at universities has become a vehicle for expression of concern about military research at universities generally, as well as about the merits and dangers of the SDI program itself. People question whether the university *qua* university and individual faculty members should accept SDI funding.

The SDI program is pursuing a vision that defensive technologies can be developed to the point where they can eliminate the danger from nuclear weapons. The program consists of a broad array of technology projects in computer hardware and software, high-energy particle and laser beams, infrared sensors, and more. SDI does not involve designing and constructing new weapons systems, as in the case of the Trident and Stealth bomber programs—the state of technology for ballistic-missile defense is not ready for that. Rather, SDI is aimed at advancing the state of the art so that a full-scale development program can begin as soon as possible. The bulk of the SDI effort is occurring in industry and special laboratories.

The scientific "distance" between what goes on in campus laboratories and the technical content of the SDI program is much less than is usual with large controversial weapons programs. Academic scientists and engineers are particularly aware of the technical aspects of the SDI program because many of the new technologies are closely related to ongoing research at campuses. University scientists and engineers can therefore make knowledgeable inferences about the technical potential of key technologies pursued by the program, as well as about its limits and likely costs.

The objections to the SDI program—objections with which I agree—relate to its political and ideological components: the stated goals, claims, and orientation of national policy that come with the program. The idea of developing a near-perfect defense against nuclear weapons is technologically absurd. And basing national-security policy on this technological fantasy, as the U.S. government is now doing, borders on the bizarre. Furthermore, deployment of a less-than-perfect ballistic-missile defense will very likely escalate the arms race. It could well divert us from political approaches that are more likely than technological fixes to lessen the possibility of a nuclear holocaust.

However, even those defense specialists who strongly oppose SDI believe that a continuing program of research and exploratory development in ballistic-missile defense is entirely in order. The United States needs to remain current on what is and is not technically feasible, and to develop the expertise to understand Soviet activities in the field. However, the content and scale of such a program should be consistent with these more modest aims. A program of appropriate scale would require no more than half of the $26 billion contemplated for five years of SDI (and no more than 1 percent of the rhetoric about the goals and wonders of the program).

Despite my own deep concern about the goals of SDI, I would urge extreme caution in restraining university research, and in pressuring colleagues on what research to

JACK RUINA is professor of electrical engineering and computer science at M.I.T. and director of M.I.T.'s program in Defense and Arms Control Studies.

ILLUSTRATION: PAUL MOCK

do and what sponsorship to accept, as a way of conveying political messages.

The Potential Tyranny of Colleagues

Even though most people are not pressing—as they might have in the 1960s—for the university itself to take a political position, they are asking their colleagues to do so. This peer pressure, even though informal, affects the intellectual climate adversely. After all, peer review is a significant aspect of the culture of academe; it quite properly influences the professional judgments of researchers. But it is inimical to the fragile academic enterprise when peer review extends to judgments of what cause is just, and collegial pressure is exercised to influence research for reasons other than academic merit.

How each of us judges our own research in the larger scheme of social goals should be an individual matter. Scientists differ in their views about the extent to which they should participate in a national program whose overall justification and goals they disagree with. Some on campus may have strong negative sentiments about accepting sponsorship from a government program when they seriously question its wisdom and motivation. Others feel no need to be defensive about accepting support from almost any legitimate government source for research they believe is inherently useful, as long as it meets university standards of openness.

My first reaction to the effort to encourage faculty members to refuse to work on the SDI program was that it was all to the good. But I have reverted to my long-held belief that the strength of the university as an independent research community, free from political and ideological pressures, should not be risked. When research is politicized, the potential tyranny of colleagues' approval and disapproval of choices raises problems. It is troublesome when individuals seek to impose their political and ethical judgments on what research should accomplish. We might pause to reflect on the political and ideological causes that could affect research areas such as reproduction, nutrition, and genetics. There is hardly any area of research that is not susceptible to political judgments. This is particularly true at M.I.T., which is heavily involved in public issues and government-sponsored research.

SDI is hardly the first national program to espouse unwarranted and misleading scientific and technological claims. Our highest political leaders have made totally unrealistic prognostications about programs to conquer cancer and to make the nation energy independent. Such claims did not discourage university researchers from accepting funds from these programs. (I realize that the ends of these programs could be viewed as benign, while the program goals of SDI are not only unrealistic but also potentially dangerous.)

> ***Academics should not seek to impose political judgments on colleagues' research.***

Defending the Academic Process

Universities are particularly sensitive to the potential tyranny of government research sponsors—and properly so. Universities must be vigilant in opposing restrictions on how and what is taught, on what is appropriate research, and on publication of research results. It is generally agreed that the university as an institution must eschew politics and ideology in determining research choices. However, the needs and interests of government agencies can create sensitive issues for universities. Government agencies might prefer to limit participation in research to U.S. citizens, for example, thus violating academic standards of openness. The objectivity of research would be impaired if such government strictures were readily accepted. Yet university research depends upon government sponsorship in large measure. Therefore, difficult issues recur and must be confronted. Vision, enlightenment, and compromise have achieved a reasonable modus vivendi that allows government agencies to accept academic freedom, and that prevents universities from being unduly "distorted" by research programs that reflect government rather than university priorities.

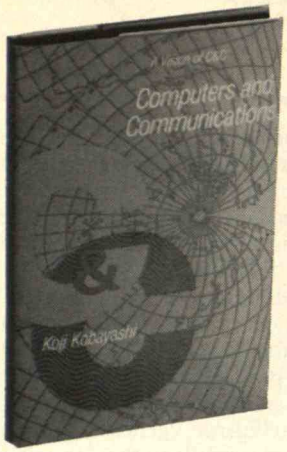
At this point there is little danger that the SDI program is large enough to seriously distort the balance of research at academic institutions. It is interesting to note that most people protesting SDI and vowing not to accept funds from the program are doing research that is unlikely to apply to SDI problems. Thus, these people's dissent will not affect their own activities and choices.

In addition to being concerned about restrictions on university autonomy and distortion of campus research priorities, many people believe that universities should not accept sponsorship by military and intelligence agencies. Most universities have guidelines that permit research for such sponsors as long as it does not violate the usual standards of openness and appropriateness. But these principles are in fact "modified" in some instances. For example, most leading universities strongly discourage work for the CIA and other intelligence agencies, even if it otherwise meets the universities' criteria. There is not enough pressure from these sources, or enough of a constituency on campus, to create an issue.

But the SDI case is not as easy to finesse. For one thing, the SDI program is making a concerted effort to involve academic researchers, and is devoting a small fraction of its budget to campus research. Although long-term unclassified campus research is hardly viewed as central to the success of SDI, it is seen as lending the program legitimacy and prestige. (This wooing of university researchers is another source of irritation to those already disaffected by SDI. But seeking to bolster support for a program through "association with prestige" is hardly unique to SDI—the tactic is even employed by groups opposed to SDI.) In addition, many academic researchers feel that SDI-funded research is in the main line of their work, and often it is work that they would like to expand. Though some have suggested that the government might attempt to restrict academic openness and freedom of publication for researchers working on SDI, these problems could probably be alleviated, as they have been in the past, by negotiation with the government.

I fervently hope that political pressure will be brought to bear on what I believe to be misguided government policy regarding SDI. However, I oppose either institutional restraints or organized peer pressure on research choices as a means of expressing political judgment about this program. Political neutrality in the choice and conduct of university research is just too important to risk. □

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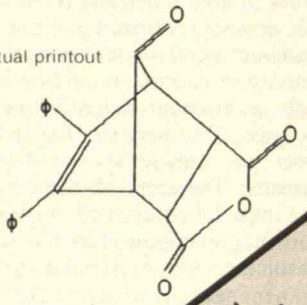
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Department of Energy to raise its support of chemistry by 250 percent, increasing from $120 million in FY 1985 to $285 million in FY 1990. And it would like the Department of Defense to boost its current support of $43 million by 10 percent a year.

An Impossible Dream

According to the report, these increases are necessary for the United States to maintain its leadership in the chemical sciences. However, persuading the federal government to grant this kind of fiscal largesse would be difficult even if the nation were as enthusiastic about chemistry as is the Pimental committee. But given chemistry's bad image, the request for such funding in the current fiscal environment seems an impossible dream.

The Pimental report was released last October. Since then chemists across the country have held NAS-sponsored regional follow-up meetings to discuss its implications. These discussions have focused largely on how to sell Congress, the administration, and the public on the need to respond positively to the report's recommendations. The perspective generally has been one of "educating" the public to the chemists' point of view.

That just isn't good enough. It is certainly not what Fernandez and his associates in the Chemical Manufacturers Association have in mind when they urge chemists to join with environmentalists, politicians, and other laypeople in working out issues of chemical safety.

Opportunities in Chemistry is an excellent report as far as it goes. But if its detailed agenda for improving living standards through chemistry is to be fulfilled, chemists will have to put the item they neglected at the top of the list. They must learn to deal skillfully with the moral, social, and political consequences of their profession.

One of the best places to equip chemists with such skills is in their undergraduate and graduate education, where students can discuss actual case histories and participate in "role play" exercises. The chemical industry does not have to wait for government to provide funds to exploit this opportunity. It can immediately encourage universities to develop such curricula and can provide the funding itself. Now that would be a "secure investment" in chemistry's own future. □

CONTINUED FROM PAGE 11

For example, to make the two budgets of both nations comparable, either dollar expenditures must be converted into rubles or ruble expenditures converted into dollars. However, two very different answers emerge depending upon which way the conversion is done. In the Soviet Union, people are cheap and equipment is relatively expensive; in the United States, the reverse is true. If we convert the American defense budget into rubles, we find that the United States—with its much smaller army but much larger hardware expenditures—is spending more than the Soviets. But if we convert the Russian defense budget into dollars, we find the Soviets—with their much bigger army but smaller equipment expenditures—is outspending the United States.

We can argue it either way because both calculations are part of the truth. But the real truth is that budget comparisons are meaningless when determining what our military spending should be.

The final point is that the United States cannot spend the Soviets into bankruptcy. The notion that the Soviets will become bankrupt in the process of trying to match our defense spending was popular at the beginning of the Reagan administration. However, one need only look at history to realize how misguided that idea is. The Soviet economy may look cumbersome and inefficient from our vantage point, but if it did not collapse in the face of Hitler's armies it is not going to collapse in the face of American military spending.

Furthermore, if the question becomes which country can draw its economic belt tighter, any gambler with a sense of history would bet on the Russians. Americans may be richer, but our willingness to sacrifice to support a huge peacetime military buildup is questionable. Yet I don't think anyone would doubt the Russians' ability to sacrifice in times of adversity.

In the end one should ask whether those who debate Star Wars are even raising the right questions. None of history's great superpowers—from Egypt through Great Britain—has ever been conquered from the outside by rivals without first declining economically. In many ways, a prosperous American civilian economy is our best military defense. The real economic case against Star Wars is that the civilian economy—battered by trade deficits that have no parallel in human history—could well use some of the time, attention, and money now being lavished on Star Wars. □



Genetics of Crime, and Mathematicians as People

The Origins of Crime

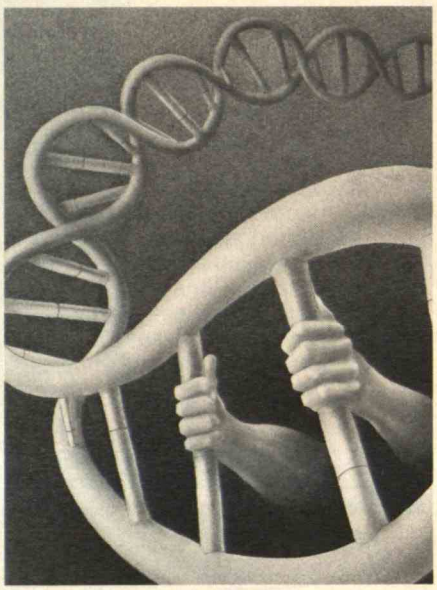
Crime and Human Nature
by James Q. Wilson and
Richard J. Herrnstein
Simon and Schuster, $22.95

Reviewed by Jonathan Beckwith

"Sloping foreheads, long arms, primitive brains" were the characteristics by which one could identify born criminals, according to Italian physician Cesare Lombroso in the late nineteenth century. Only a few decades later, U.S. eugenicists claimed that they had uncovered scientific evidence that the tendency to commit crime was genetically based. Such theories have reappeared regularly in this century, only to be rejected after close scientific scrutiny. The latest and perhaps most comprehensive effort to establish a relationship between a person's genetic inheritance and the tendency to commit crime is *Crime and Human Nature,* by psychology professor Richard Herrnstein and government professor James Q. Wilson, both of Harvard.

Wilson and Herrnstein maintain that crime runs in families because of genetics. They conclude that "family socialization and (perhaps) schooling" may also help determine whether people become criminals, but they deny that the larger socioeconomic environment plays much of a role. (Significantly, Wilson and Herrnstein focus on high-rate offenders who commit violent crime; they do not include white-collar and other types of crime.) The authors review an immense number of studies to support their views. However, they exaggerate the conclusions of studies that support their thesis and ignore or discredit those that lead to other conclusions.

For instance, they cite a study that found that 5 of 12 XYY males—those with an extra Y chromosome—had arrest records. Yet 3 of the 5 were "not serious criminals," according to the study's authors, having a small number of arrests for offenses such as calling in a false fire alarm while drunk. The authors still generalize this result to imply a "genetic ingredient in criminal behavior." Similarly, they ignore criticisms of a report in *Science* that found that the level of criminality among adopted children correlates with that of their biological parents. The study did not take into account the fact that agencies often place adoptive children with families with backgrounds similar to



those of their biological parents.

Wilson and Herrnstein also revive the theories of William Sheldon, who postulated that short, heavy-boned people tend to become criminals. Yet the authors fail to mention that most scientists doubt the significance of Sheldon's claims. Wilson and Herrnstein admit that many of the studies they cite have "inherent weaknesses and flaws," and talk of setting "our expectations for these data at a realistically low level," but then use those studies to arrive at the "true facts of the matter."

The authors claim that "it would be hard to find a serious contemporary student of these topics" who would not agree that there is a "substantial" genetic contribution to many aspects of human behavior, including intelligence. However, whether intelligence is genetically based is an open question: many scientists would maintain that there is no way to separate environmental from biological factors to prove or disprove such a statement. The authors ignore the fact that most of the studies that purport to link IQ with genetics have been widely criticized. Moreover, they fail to mention studies in France and the United States that have found that the IQ scores of children from poor backgrounds rise markedly after they are adopted into families of a higher socioeconomic class.

The authors take off their kid gloves when analyzing studies that link economic and social influences with criminality: in this case flaws as serious as those raised by the biological studies become fatal. Most striking is their cursory treatment of cross-cultural studies—a technique that they say is "one way social scientists compensate for not being able to do genuine experiments." Of course, many people would argue that marked differences in the crime rates of different societies are evidence of strong environmental influences on criminal behavior. However, the authors circumvent the issue by lumping together statistics for all developed countries and comparing them with those for all developing countries. The only two countries they specifically compare are Japan and the United States, reporting that the U.S. robbery rate has recently *narrowed* to 125 times that of Japan, while the number of murders in Japan in 1982 was 13. Although they admit that cultural differences may help explain such stunning disparities, they suggest that the cultural contrasts themselves may stem from the different biological inheritances of the two countries. While such an explanation is not inconceivable, they go out of their way to avoid the more obvious conclusion that social factors are at work.

How to Prevent Criminality

In the United States, criminals have been sterilized and women have aborted XYY fetuses because of arguments that criminality is genetically based. Surprisingly, Wilson and Herrnstein come down on the side of using environmental influences to deal with criminality. They advocate the use of early-childhood-intervention programs such as Head Start, and conclude that "parents should not deprive their children of affection or be inconsistent in rewards and punishments." The authors appear to have learned the major lesson of the "IQ wars": that saying a trait has a genetic component does not preclude efforts to control its expression.

It is not clear, then, that the authors' effort to link crime and biology is worth the effort. Their suggestions might just as well come from those who support a sociological explanation for criminal behavior. In fact, their main target appears to be those who suggest that fundamental aspects of our social system are a major cause of our high crime rates. They open the book by saying that "what needs explanation is not the behavior of society but the behavior of the individuals making up society." Perhaps they minimize cross-cul-

"When I have just gained some new mathematical insight, I find more meaning in everything."

tural evidence because such comparisons might suggest the need for widespread social change, including greater equality of access to adequate housing, schooling, and jobs.

The results of scientific research must pass through a series of filters before reaching the public. Those filters include the methods scientists choose to conduct their research and the interpretation they give to their results, peer review of this work, and decisions by the media as to which results to report and how. Ideally, these filters should prevent all but the latest scientific "truths" from reaching the public.

In reality, personal biases and prevailing social attitudes can distort each of these filters so that the public receives only a very biased view of the facts. Wilson and Herrnstein examine their subject through filters clouded by a hereditarian point of view. (Herrnstein has previously suggested that social classes are "built on inborn differences.") The authors have performed the valuable service of compiling the results of an enormous variety of research, but they have failed to settle an old controversy. □

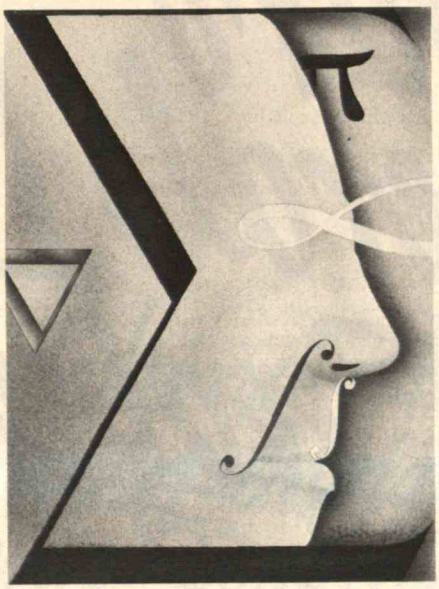
JONATHAN BECKWITH is American Cancer Society Professor in the Department of Microbiology and Molecular Genetics at Harvard Medical School.

The Personal Side of Mathematics

Mathematical People
ed. by Donald J. Albers
and G.L. Alexanderson
Birkhauser, $24.95

Reviewed by Frank Morgan

Unless your next-door neighbor happens to be a mathematician, you won't find a more human introduction to mathematics than *Mathematical People*, edited by Donald J. Albers and G.L. Alexanderson. The book relies on short, lively interviews instead of scholarly biography to dramatize the daily lives, work, and hopes of some 20 modern mathematicians. This technique works especially well since mathematicians are notorious even among themselves for turning a bright conversation into unrecognizable scholarly prose once they put their ideas on paper.



Harvard mathematician Garrett Birkoff seems to sound the mathematician's motto with his opening remark: "I was always interested in everything." All the mathematicians in these pages reveal the vigor and variety of their interests, which range from magic to writing and music.

Persi Diaconis, Stanford statistician and MacArthur fellow, talks about the open-minded searching he had to do to become a national clearinghouse for solving problems in many different fields. Now he has "a stream of people from all walks of life—psychologists, biologists, mathematicians—coming in saying: 'Hey, do you know about this?' " As you get to know Diaconis better, you realize that he takes such an active interest in so many fields not just because it is his vocation but because it is his nature. He began studying violin at Julliard at age 5, practicing after school and on weekends. At age 14 he left home with two days' notice to follow the great magician Dai Vernon, and he spent the next ten years on the road practicing magic before deciding to pursue mathematics.

Ronald Graham, head of Bell Labs' Mathematical Studies Center, also attests to the breadth of many mathematicians' interests. Graham is a pianist, bowler (with a couple of perfect 300 games), boomerang thrower, ping-pong player, parachute jumper, trampolinist, and juggler (past president of the International Jugglers Association). He received the prestigious Polya Prize for his work in Ramsey theory, a branch of mathematics dealing with large combinations of objects.

Here is an example of the kinds of problems he thinks about. It sounds easy at first but no one has been able to answer it yet. We know that in any group of six people, either some three of them all know one another or some three are all strangers. No matter what the nationalities and histories of the six people, one of those alternatives has to hold. The unsolved question is: How big a group of people is required so that either some five all know one another or some five are all strangers? Again, you must find a number, doubtless much higher than six, for which one of the alternatives has to hold regardless of the circumstances of the individuals. If you can find the answer, you'll probably appear in the next edition of *Mathematical People*.

Solving such problems requires tremendous energy and resilience, because most ideas lead down blind alleys and most efforts prove fruitless. Herbert Robbins, a statistician at Columbia University and coauthor of the marvelous book *What Is Mathematics?*, describes a disquieting question that mathematicians often confront: "What did I do today? I talked to a few people. I tried to think about something and it came to nothing. Finally, I found that I was just repeating what some other researcher had already done."

Almost anyone who has taken a mathematics course can appreciate this struggle. However, when the light dawns, the satisfaction can be immense. David Blackwell, a statistician at the University of California at Berkeley, calls the search for such understanding, above his interest in any applications, his reason for doing statistics.

Indeed, Paul Halmos of Indiana University, editor of the *American Mathematical Monthly*, defines mathematics as "Truth. Beauty. Insight. Structure," with "everything new the mathematician hears eventually sounding like something else that he doesn't know." He predicts that if all men and women would understand some mathematics, "They would enjoy life more, they would understand life more, they would have greater insight."

The joy of pursuing such insight, and the meaning it gives to other aspects of life, is illustrated by a recent trip I made to Los Angeles, a realm unfamiliar to me. A friend met me at the airport, and we drove a few miles up the Pacific coast. As

Continued on page 67

ILLUSTRATIONS: MICHAEL YOUNG

Toward Liberal Learning for Engineers

By Samuel C. Florman

Most American engineers have not read the "great books" of Western civilization or studied the history of their nation or any other. They are not acquainted with philosophy or the fine arts, and they have not explored any of the social sciences in depth. This is so because the standard engineering degree is a bachelor of science earned in a four-year undergraduate program in which the traditional liberal arts are rarely given significant time or meaningful attention. And in postgraduate programs, pursued by about a quarter of today's engineers, the liberal-arts content is nil. The fact is that engineers are not receiving essential elements of a traditional college education—and this is occurring at a time when more and more of their fellow citizens are doing so, and when engineers need to be better informed about the world around them to function effectively.

The comparison with other professions is particularly disturbing. Doctors, lawyers, dentists, and veterinarians must receive bachelor's degrees before entering professional schools, and many other professionals—including business managers, architects, and journalists—are encouraged to do so. Engineers share with accountants, teachers, and nurses the problems inherent in structuring professional training within an undergraduate format.

There is nothing new about dissatisfaction with the vocational nature of engineering education. But long-standing concerns are now being voiced with new intensity. A 1984 report sponsored by the National Institute of Education calls for all recipients of bachelor's degrees to have at least two full years of liberal education, and urges professions such as engineering to extend their programs accordingly. At its 1985 education conference, the American So-



Enriching the human experience of engineering students depends upon the vision of elite schools, innovative teachers and committed students.

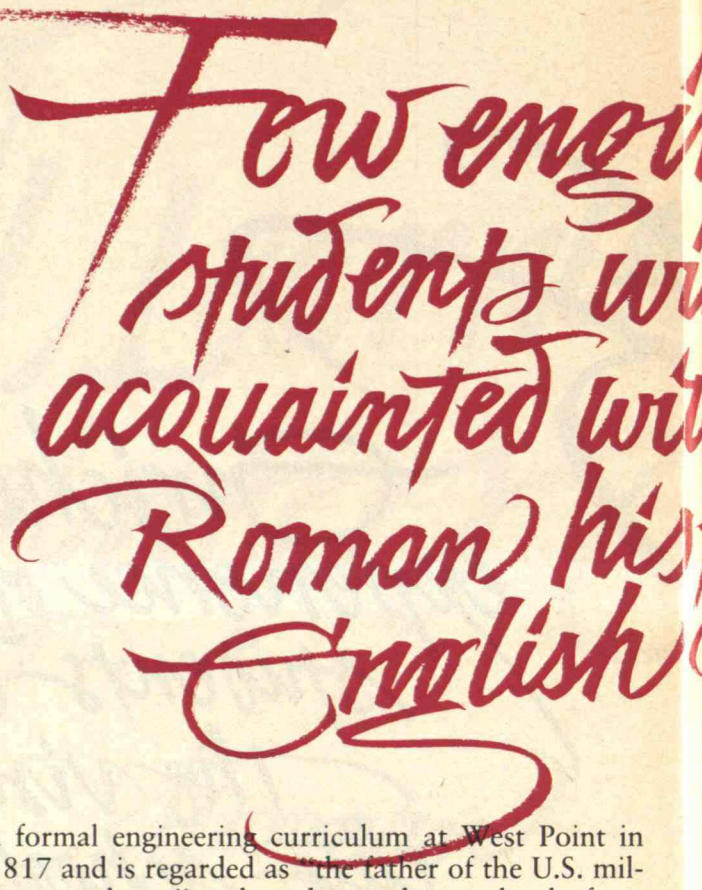
ciety of Civil Engineers formally recommended a five-year course, including more liberal-arts courses, for entry into the profession. Many members of the engineering community have endorsed this concept, some even opting for a six-year program, and other engineering educators are considering ways of increasing the liberal-arts content of the existing four-year format.

Yet the arguments opposing drastic change—pragmatic, economic, don't-tinker-with-success arguments—are extremely compelling. I have visited some 40 colleges, universities, and technical institutes and attended a goodly number of professional-society meetings over the past ten years. I have found very mixed attitudes toward liberal education among engineering deans, professors, and students, as well as among employers of engineers. The high-sounding platitudes one hears at seminars and reads in professional journals are frequently disparaged in off-the-record conversations. Even some of those who truly respect the concept of liberal learning for engineers fiercely resist increasing the time and expense required to obtain an engineering degree. (Many students already spend four and a half years, and more, completing the nominal four-year course.) Indeed, I have concluded that no major profession-wide change is politically feasible at this time. I am also not certain that the nation—or the students and their families—could afford a sudden 25 percent increase in the cost of educating engineers.

However, there is no question in my mind that engineering education should be liberally enriched, and that an increase in the length of the entry-level program would bring enormous benefits. Engineers require a more liberal education if they are to maintain their rightful place as professionals. Since such

CALLIGRAPHY BY COLLEEN

change is unlikely to be pressed by the profession through its accreditation program, individual engineering schools must take the lead, moving at different paces and possibly even in different directions to increase the liberal-arts content of their curricula.



An Apprenticeship Tradition

Engineering education began in America under circumstances that differed markedly from those of the other leading professions. Schools of medicine and law, for example, were established by practitioners and then somewhat loosely affiliated with universities. In contrast, sponsorship for engineering schools came from the government (the U.S. Military Academy in 1802 and the land-grant colleges starting in 1863), from public-spirited citizens who founded technical institutes (including Rensselaer Polytechnic Institute and the Massachusetts Institute of Technology), and from within universities, where engineering departments seem to have been created in response to faculty interest or student demand. Thus, engineering education was from the beginning undergraduate education, and the idea of getting a college education *before* going to professional school never took hold.

Meanwhile, an apprenticeship system for training engineers already existed. Indeed, the first American "schools" of engineering were canal-construction projects. There underlings such as surveying assistants learned on the job, progressing through the ranks until their mentors deemed them worthy of the title "engineer." This tradition continued on the railroads and in factories and machine shops long after college engineering programs were established. As late as 1916 half of American engineers had never been to college at all, and many regarded formal engineering education as unneeded competition for the apprenticeship system. Practicing engineers and educators of engineers were two different breeds, and debates between representatives of the "shop culture" and the "school culture" were often intense.

Sporadic efforts to establish engineering as a postgraduate discipline like medicine and law have never had lasting effect. Sylvanus Thayer, who introduced a formal engineering curriculum at West Point in 1817 and is regarded as "the father of the U.S. military academy," endowed a graduate school of engineering at Dartmouth College in his later years. He intended that students enroll in the Thayer School's two-year program after obtaining a traditional college degree. Eventually the school combined the senior year of college with the first year of engineering school, and Dartmouth's curriculum, still in existence, became what is known as a 3-2 program. Today Dartmouth is unique in requiring students to acquire bachelor of arts degrees on the way to engineering degrees.

Several other institutions experimented with this model but all reverted—largely under economic pressures—to four-year curricula. However, a number of engineering students voluntarily pursue 3-2 programs, mostly by attending liberal-arts colleges for three years and then transferring to engineering schools. Some engineering schools have formal arrangements whereby such students are assured B.A. degrees from the liberal-arts institution as well as B.S. degrees in engineering. Washington University in St. Louis, for example, has such an association with some 80 liberal-arts colleges. But only about 5 percent of all engineering graduates now take this approach: the four-year bachelor's degree is the standard.

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Engineering in the Ascendancy

The four-year engineering curricula of a century and more ago allowed ample time for both liberal learning and technical training. There was no great abundance of engineering subject matter; indeed, there were a paucity of engineering texts and a shortage of qualified professors. Moreover, early engineering educators—notably Benjamin Franklin Greene at Rensselaer, William Barton Rogers at M.I.T., and Andrew Dickson White at Cornell—perceived the liberal arts as an integral part of any professional education. Languages and humanities courses accounted for one-third of M.I.T.'s first mechanical engineering program.

However, with the rapid growth of engineering knowledge and the expanding technical needs of a young nation, the competition for time intensified between the professional and liberal components in the engineering curriculum. Engineering educators have been grappling ever since with the problem of stuffing more and more technical content into four-year curricula while trying to maintain the elements of a traditional college education. Unfortunately, the liberal arts have been relentlessly pushed aside.

The Morrill Act of 1862, which established the land-grant colleges, unintentionally contributed to the weakening of liberal studies in engineering curricula. As the act intended, most of the students who flooded into these new institutions were young men of humble origins, sons of rural or blue-collar families to whom the arts and humanities held little appeal. Gradually such attitudes became prevalent throughout the profession. By 1916 a professor of English at M.I.T. lamented that engineers viewed "culture" as "a pose, impressive perhaps with some women, but scarcely effective among men." As late as the 1950s a professor at the City College of New York observed that engineers tended to be "rough, tough spirits" who took "pride in cultivating construction camp and barroom manners rather than the deportment that would grace a drawing room." The research department of Deutsch and Shea, Inc., analyzing a number of psychological studies, drew an unsettling profile of 1950s engineers: "Constricted interests are apparent in their relative indifference to human relations, to psychology and the social sciences, to public affairs and social amelioration, to the fine arts and cultural subjects, and even to those aspects of physical science which do not immediately relate to engineering." Despite these concerns, the narrowing of engineering education under the pressure of new technical subjects continued unabated.

The Bias Toward Utility

Accreditation of university engineering programs was not formally established in the United States until 1932, when the Engineers' Council for Professional Development(ECPD)—recently renamed the Accreditation Board for Engineering and Technology (ABET)—was established. ABET represents the nation's 19 major technical and professional engineering societies, whose membership on the board of directors is roughly proportional to the number of their members. The board develops minimum criteria for undergraduate engineering programs and accredits them after thorough reviews of each school's curriculum, including on-site visits.

ECPD was largely occupied in its early years with battles over whether engineering curricula should emphasize science or hands-on engineering, research or practice, theory or design, and specialization or broad basics. Thus, the council took no action when, in the early 1940s, a report from the Society for Promotion of Engineering Education recommended that at least 20 percent of engineers' courses be in

humanistic and social studies. Not until 1955 did ECPD recommend that at least 12.5 percent of the total curricula—the equivalent of one-half year out of the four—be devoted to liberal arts. However, even this proposal provoked cries of protest from many institutions, and ECPD had to assure them that this was merely a "statement of principle." A school that failed to achieve it need not fear loss of accreditation.

Still, by 1971 recommendation had become requirement, and today all accredited engineering curricula must include at least a 12.5 percent liberal-arts component. Some schools—notably Ivy League schools, M.I.T., Stanford, and other private institutions—require that engineering students take 20 percent or even slightly more of their courses in the humanities and social sciences. But at most of the large universities where the vast majority of America's engineers are trained, the minimum has become the maximum. This means that of a total of about 45 courses, the average engineering undergraduate takes some 6 courses in the liberal arts, plus perhaps a utilitarian course in speech or composition. And most of those 6 courses are likely to be taken in "useful" social sciences such as economics, psychology, and sociology. Furthermore, most students see this work fulfilling the so-called "ABET requirement" as a hurdle to be overcome, a chore to be attended to, en route to their degrees.

A generation ago this meager portion provided students with at least a modest introduction to general culture, since broad survey courses, such as those on Western civilization or great works of literature, were common in engineering programs. But these courses fell into disrepute in the 1960s, with some academics regarding them as superficial and lacking in rigor. ABET responded to this concern for depth by requiring some of the nontechnical study to be at an "advanced" level. Thus two or more of the precious six liberal-arts courses must now be in the same field of study. This is a worthy concept, to be sure, as is the development of interdisciplinary subjects such as engineering ethics and technology in society. But these trends have served to eliminate from the engineering curriculum courses in literature, history, and philosophy, fields that are the very essence of liberal education. The likelihood is now minimal that most engineering students will ever become acquainted with Greek drama, Roman history, or the English novel.

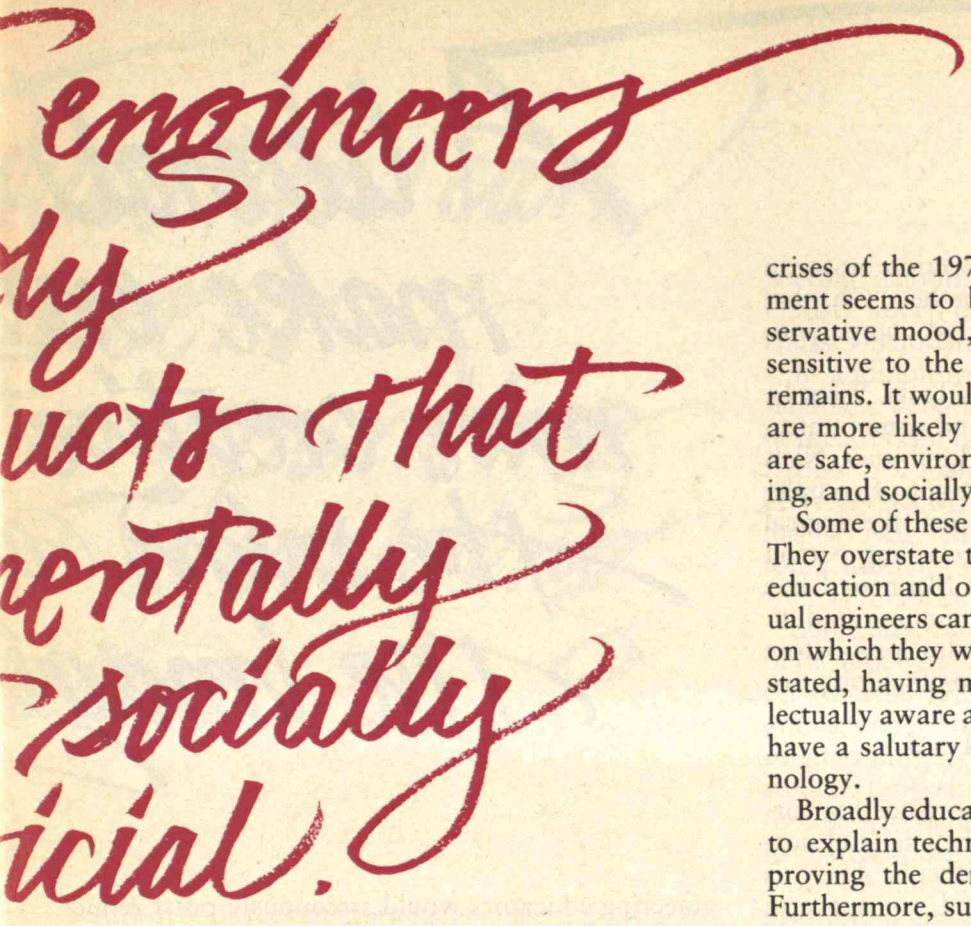
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ABET does not accept "skill" courses (such as accounting) toward the 12.5 percent liberal requirement. But the bias toward utility was reflected just last year when ABET shifted introductory language studies out of the "skill" category into the liberal-arts component. It is also reflected every year by the choices of students and their would-be employers. Most of the young engineering students I meet want to maximize their immediate chances in the job market and minimize the cost of pursuing their degrees. They are not at all convinced that the humanities are relevant to their concerns. And corporate employers, for all their proclaimed interest in the liberal arts, are content to hire graduates with a limited background, sometimes using them for subprofessional jobs.

New Reasons to Seek an Old Goal

The fact that most undergraduate engineers are not being offered anything like a true college education does not prevent them from serving the nation well—extremely well. But longstanding concerns that college should give engineers a broader educational experience now have added urgency.

One reason is the growing need for engineers to be able to communicate in order to be effective. As the technical complexity of engineering has grown,



so has the need for engineers to work together—to listen, understand, explain, persuade, and empathize. Engineering is more of a team effort than it used to be. Furthermore, as technology takes an ever-larger role in corporate, national, and world affairs, the audiences for engineers' communications become more diverse. Donald A. Rikard, vice-president of Dow Chemical Co., notes this need: "The technical graduate entering industry today will, in all probability, spend a portion of his or her career explaining technology to lawyers—some friendly and some not—to consumers, to legislators or judges, to bureaucrats, to environmentalists and to . . . representatives of the press." Walter Vogel, executive vice-president of Deere and Co., emphasizes his company's future demand for "engineers who are articulate, who can write and speak concisely, effectively and persuasively," and who will "not be subject to cultural shock if involved in projects in the Middle East, the countries of the Communist Bloc, or even the People's Republic of China."

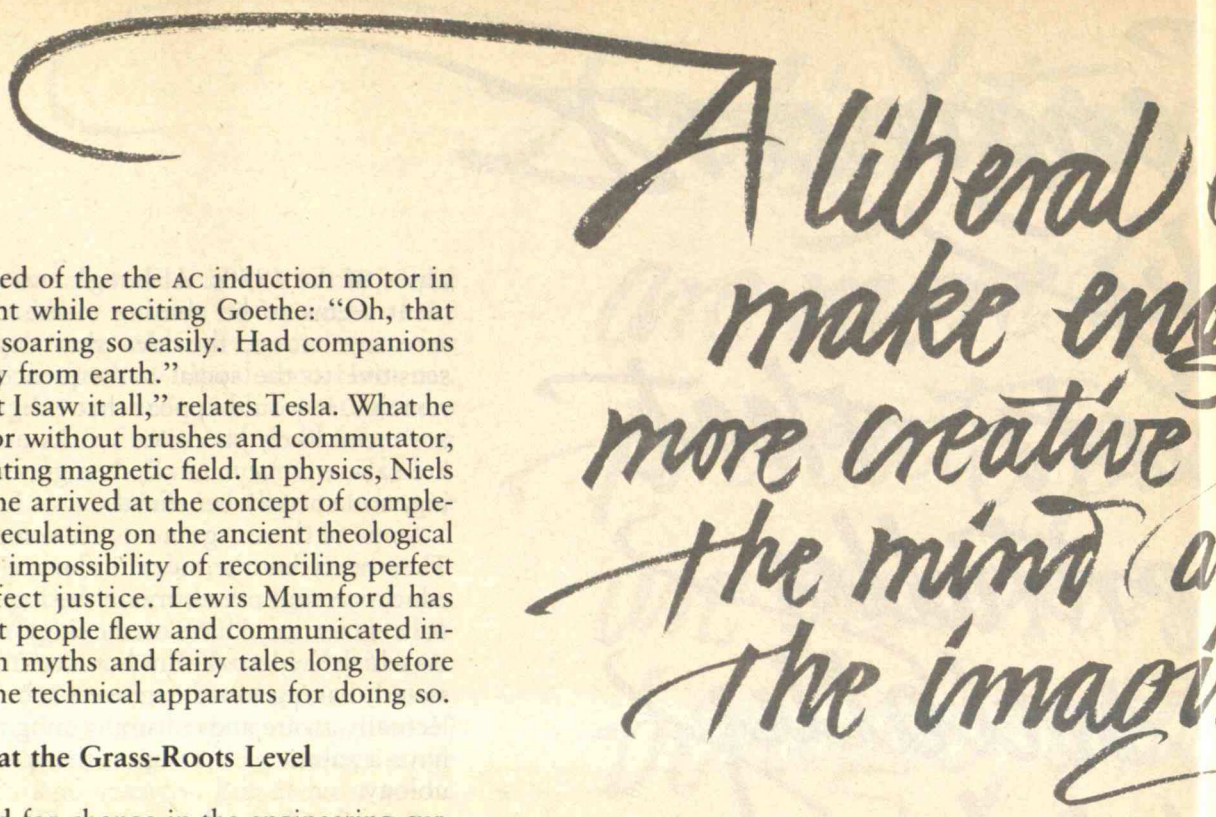
Indeed, broadly educated engineers in leadership roles will bring renewed respect for creative technical enterprise. Engineers today need to be more psychologically and culturally perceptive to deal with the fear of "technology" that emerged with the development of nuclear weapons. This suspicion intensified in the wake of the energy and environmental crises of the 1970s. Although antitechnology sentiment seems to be abating in the current neo-conservative mood, the idea that engineers must be sensitive to the social consequences of their work remains. It would appear that enlightened engineers are more likely to create works and products that are safe, environmentally benign, esthetically pleasing, and socially beneficial.

Some of these arguments are somewhat simplistic. They overstate the moral influence of a humanistic education and overestimate the impact that individual engineers can have on the shape of the technology on which they work. But however the arguments are stated, having more engineers who are more intellectually aware and culturally enlightened will surely have a salutary effect upon the quality of our technology.

Broadly educated engineers will also be better able to explain technology to their fellow citizens, improving the democratic decision-making process. Furthermore, such engineers will have more opportunities to assume the leadership roles now occupied by lawyers, business managers, journalists, and politicians. Our society is led almost exclusively by men and women who have received liberal-arts college educations. This may be due partly to custom and snobbery. But it could hardly be otherwise, for it is liberal education that transmits a sense of tradition, history, and ideas and a broad understanding of the world—the shared knowledge and values that bind our society together. In this technological age our society needs technically knowledgeable people in its highest councils. I believe that increasing the number of engineers qualified by both training and experience for such roles would improve the well-being of the American commonwealth.

Finally, liberal education will bring to the individual engineer delight in the arts and the precious insights of literature, history, and philosophy. Many engineers in their mature years regret having neglected these concerns. It is also paradoxical but true that a humanistic education can help them appreciate the satisfactions inherent in their own work.

Indeed, a liberal education can make engineers technically more creative by expanding the mind and exercising the imagination. Although a case can be made for the creativity of the obsessively single-minded engineer, there are many examples of scientists and engineers who took inspiration from humanistic and artistic thought. Nikola Tesla claimed



to have conceived of the the AC induction motor in a flash of insight while reciting Goethe: "Oh, that spiritual wings soaring so easily. Had companions to lift me bodily from earth."

"In an instant I saw it all," relates Tesla. What he saw was a motor without brushes and commutator, turned by a rotating magnetic field. In physics, Niels Bohr said that he arrived at the concept of complementarity by speculating on the ancient theological dilemma of the impossibility of reconciling perfect love with perfect justice. Lewis Mumford has pointed out that people flew and communicated instantaneously in myths and fairy tales long before they achieved the technical apparatus for doing so.

Soul-Searching at the Grass-Roots Level

Despite the need for change in the engineering curriculum, long-standing prejudices, beliefs, and academic politics make innovation difficult. There is serious competition, as I have noted, for space in increasingly crowded engineering curricula, and engineering faculty are understandably reluctant to condense their teaching. Moreover, in schools with strong, independent liberal-arts departments, the best faculty are concerned with teaching, writing, and performing research within their own specialties. Most take little satisfaction, and gain little professional benefit, from teaching literature or history to engineers. Where small liberal-arts groups are designated to teach engineering students, the distinction and pride of liberal-arts departments is missing. In either case, engineering faculty have considerable influence over the way engineering students perceive their liberal studies. Too often, these educators, concerned that American innovation, quality control, and productivity have declined and that their students be prepared to help reverse this trend, do not see the humanities as subjects of high priority.

Still, the ideal of liberal education for engineers retains considerable vitality. The topic regularly appears on the agendas of engineering societies' meeting and is the subject of continuing studies and reports. At ABET's annual meeting in Phoenix last October academics and employers alike appealed for liberalized engineering education. Yet the deliberations at the meeting made it clear to me that the focus of the battle must be shifted away from the narrow confines of ABET accreditation. Many engineering educators would strenuously resist reducing by even one course the technical content of their curricula. Moreover, it is no longer appropriate to train all engineers in the same way. The profession should acknowledge that a spectrum exists ranging from solid, useful, technically adept engineers at one end to socially involved, culturally sensitized engineers at the other. The ideal is to have all members of the profession move toward literacy and cultural and humanistic sensibility while rising to new heights of technical skill and ingenuity. But, as engineers, we pride ourselves on our sense of reality, and rather than spend more time and energy in rhetoric let us get on with that part of the ideal that is now within our reach.

I conclude that the next step in liberalizing engineering education will occur through the soul-searching of individual institutions. For example, at M.I.T. several committees are actively considering ways to better integrate a traditionally strong humanities program with the school's engineering curricula. Engineering students at M.I.T. already take at least eight courses (20 percent of a typical undergraduate curriculum) in the humanities and social sciences. They choose from a broad range of fields, including anthropology and archeology, economics, foreign languages, history, linguistics and philosopy, literature, music, political science, psychology, and writing, and there are distribution and concentration requirements.

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Any school reexamining its engineering program would do well, in my opinion, to look closely at what Stanford University has done. The school recently restored a program in Western civilization that was abandoned in 1970 after having been part of the currriculum for 35 years. All undergraduates must enroll in this grand year-long, three-course journey from classical antiquity to the modern age. Students can choose from among three emphases—history, literature, and technology and society—as the program acquaints them with the significant cultural eras, the notable creators, and the important ideas that are our heritage. All Stanford undergraduates must also fulfill seven other requirements—three that engineers automatically fulfill (mathematics, science, and technology) and four others in the humanities, social sciences, and fine arts. At least one course must emphasize a non-Western culture. Stanford also requires that students take two writing courses and show minimum competence in a foreign language. In pursuing this program the typical engineering student earns 23 percent of his or her credits in non-technical areas.

In answer to the critics of so-called survey courses, I can only reply that there is more depth to be found in a few days with Shakespeare or Thucydides than in four years with the statistics of most social scientists. The restoration of such courses to their rightful place of honor at Stanford could be a catalyst for the rebirth of humanistic learning in all engineering schools. Columbia University, to its great credit, never did abandon its famous required courses in humanities and contemporary civilization.

In addition to course offerings, activities such as seminars, debates, plays, concerts, and experiments in the arts can help widen engineering students' horizons. L.S. Fletcher, associate dean of engineering at Texas A&M, urges young engineers to travel and has himself led engineering students on summer tours abroad, studying cultural characteristics as well as important engineering sites.

Some advocates are not satisfied with enrichment of the four-year curriculum, no matter how well conceived. They prefer instead to push for five-year programs, either similar to the Dartmouth 3-2 plan or original in design, to provide more time for liberal studies. I myself vigorously endorse the concept, although I recognize the economic realities that make its nationwide adoption impractical at this time. However, any of a score of the more select private institutions have the resources and the guaranteed student body needed to carry out such an experiment. It is no longer true, if it ever was, that all institutions must go to five-year programs at the same time if the move is to succeed. New 3-2 programs would be stronger if they culminated in master's degrees. The combination of two bachelor's degrees, one in liberal studies and one in engineering, is not adequate recognition for an engineer who has received a full-fledged liberal education.

Students themselves may do much to affect the shape of engineering. A recent National Research Council report notes that today's engineering students "have a richer educational and cultural background and are more confident, more assertive than engineering students of years past." Perhaps some of these able young men and women will look at the world around them and decide that the academic path laid out before them does not satisfy their talents or their aspirations. By their choices—and their demands—they may help to shape a richer curriculum and a more noble profession.

Eventually, when there are successes to point to and role models in place, and when economic constraints seem less forbidding and the mood less confrontational than at present, ABET can consider changing its accreditation requirements. In the meantime, all thoughtful engineers can play a constructive role by fostering discussion and nurturing respect for the liberal arts. □

The Art of TYPOGRAPHY IN THE INFORMATION AGE

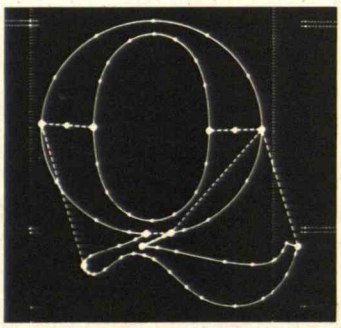
BY CAROLINE CHAUNCEY

TYPOGRAPHIC design is a paradoxical art. Its principal goal is to be transparent: the letters themselves must not distract the reader from the text. A well-designed typeface "should be sublime in appearance but subliminal in effect," says Donald E. Knuth, a Stanford University professor of computer science who has worked on computer-aided systems for type design.

Over the centuries, designers have developed graceful, legible typefaces for books, magazines, and newspapers. Well-designed typefaces enable people to read texts fluently, recognizing the shapes of entire words instead of laboring to discern each character.

Unfortunately, as more and more text is presented on video screens and computer printouts, readers often find themselves halting and stumbling over letters. The art of letterform design—or rather the lack of it—is becoming all too visible.

For example, the typefaces displayed on the screens of many personal and office computers are among the worst. In some of these typefaces, letters such as *g* and *y* are not allowed to extend below the baseline but are unceremoniously squeezed



into the same space as an *x*. And the characters are inconsistent: the space inside a *p* may be a fifth as large as that inside an *o*. In other typefaces, *p*, *q*, *d*, and *b* look like mere rotations of the same form.

Poor letterform design may contribute to eyestrain, headaches, and fatigue in users of video-display terminals (VDTs). "In the nineteenth century the workplace was a hostile environment for people's arms and fingers," says Charles Bigelow of the Bigelow & Holmes design studio in San Francisco. "Now it is the visual environment that is hostile." All of us would read and work more efficiently if this were not the case. Surveys have shown that improved typefaces can increase readers' speed by as much as 30 percent, says Robert Ebberson, a manager of type marketing at Compugraphic of Wilmington, Mass., a firm that sells typesetting equipment and adapts typefaces for it.

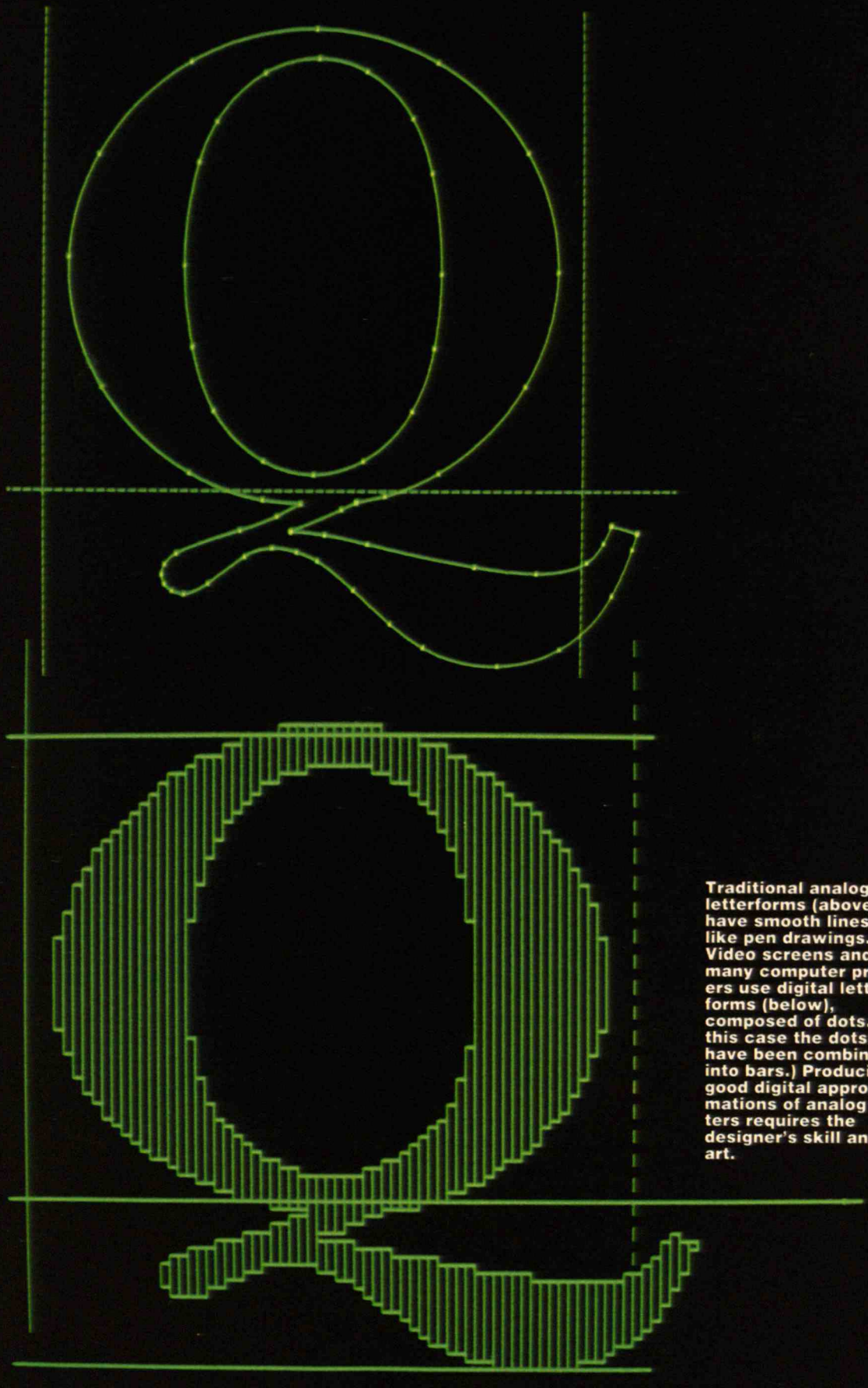
The shift to digital printing techniques is responsible for a great deal of this poor letterform quality. Traditional letterforms are analog: the movement of a pen or the impression of metal type creates a smooth line. A few publishers such as David Godine in Boston sometimes still use metal type for aesthetic reasons, despite the expense. Other publishers use analog photocomposition, a photographic analog typesetting process. And many computer printers are analog: type on a "daisy wheel" strikes a ribbon to print letters.

But in digital typography, which is becoming more and more common, each character is composed of a series of dots like the letters in a stitched sampler. Most magazines, newspapers, and books are digitally set by cathode-ray-tube (CRT) typesetters, which have been used since the mid-sixties, or high-resolution laser typesetters, which have become common more recently. The cathode-ray tube in a CRT typesetter is much like a television tube but produces a much finer image. An electron beam in the tube scans a pattern of lines, which are themselves composed of

CAROLINE CHAUNCEY is an editor at Dollars & Sense, *an economics magazine.*

Like everything else, type design has gone digital. Poor design makes many digital typefaces difficult to read, but the ancient art of typography is coming to the rescue.

PHOTOGRAPH: COMPUGRAPHIC CORPORATION



Traditional analog letterforms (above) have smooth lines like pen drawings. Video screens and many computer printers use digital letterforms (below), composed of dots. (In this case the dots have been combined into bars.) Producing good digital approximations of analog letters requires the designer's skill and art.



dots. The beam illuminates patterns of dots that form letters on a phosphorescent screen. The letters are exposed on photographic paper or film, which is developed to produce the "galleys," or columns of text. In a high-resolution laser printer, a laser forms the letter. In this case, too, the image is exposed on paper or film and developed to produce galleys.

In such typesetting equipment, the resolution—the number of dots available to make up each character—is so high that the output approximates the smooth look of analog letterforms. Lower-resolution devices, such as video terminals and dot-matrix computer printers, pose greater problems for designers. As the number of dots per character decreases, smooth strokes break down into stair steps, and subtle details vanish.

Ironically, low-resolution typefaces have received the least attention from designers. Characters displayed or printed by personal and office computers are usually generated right in the machines' hardware. Most often the same engineers who developed the hardware designed these typefaces. The engineers "didn't think of the letterforms as important," says designer Charles Bigelow. "They thought the hard part was getting the machine to work." Even when manufacturers of video screens and printers do go to professional designers, they almost "never think about type until it's too late," says John Schappler, an independent type designer. "Then they want it overnight."

Medium-resolution laser printers—employing different technology from high-resolution laser printers—produce typefaces of intermediate quality. These printers form characters by using a laser that generates a pattern of illuminated dots, and they print text through an inexpensive photocopying process.

Like high-resolution devices, medium-resolution laser printers can produce many type sizes, weights, and faces, as well as a wide variety of graphic forms. The computer-graphics boom and the reduced costs of medium-resolution laser printers are igniting a burst of in-house publishing. Public-relations departments, engineering firms, and other operations can print everything from simple fliers to glossy illustrated brochures and complex technical manuals. Anne Roe-Hafer, marketing director of Bitstream, Inc., a Cambridge, Mass., firm that adapts typefaces for digital equipment, projects that supplying the equipment for in-house publishing will be a multi-billion-dollar industry.

Aware of this market and of the problems with low-resolution devices, manufacturers of computers and printers are "just catching on to making documents look good," says Rick Berzele, product manager at Digital Equipment Corp. "Speed, processing ability, and cost of personal computers are all more or less equivalent," says Ted Clausen, an independent type designer in Cambridge, Mass. He believes that high-quality type "could provide a significant competitive edge."

The Spaces Between

The art of letterform design is ancient and inherently conservative: the survival of literacy requires that letterforms be recognizable over centuries and even millenia. Most of the letterforms we use are, in fact, thousands of years old. The uppercase alphabet is based on Roman letters dating back to the time of Augustus Caesar, while Charlemagne's scribes codified the lowercase alphabet.

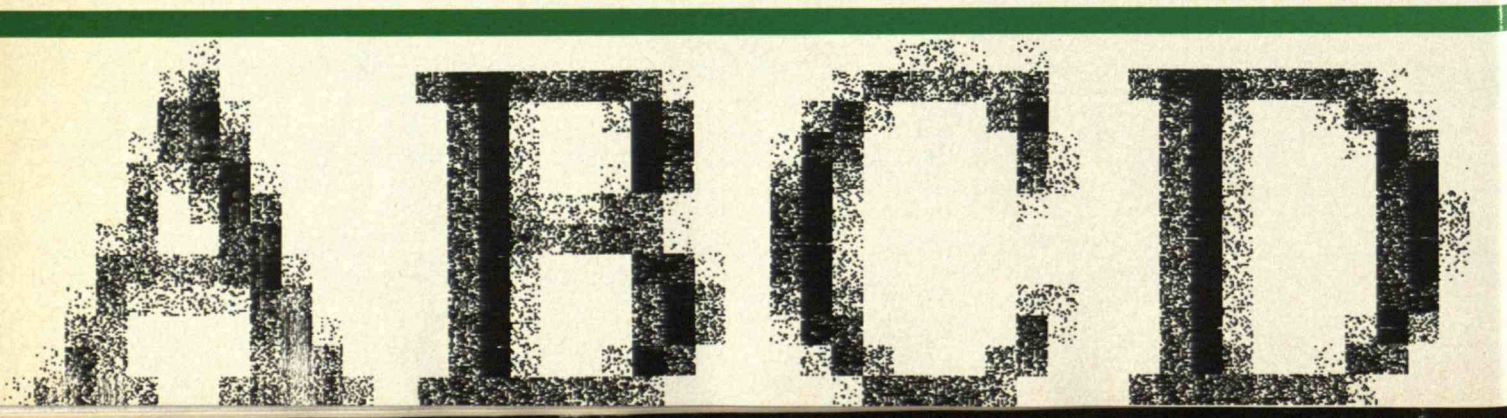
Early printers achieved continuity with the past by imitating many effects of handwriting. We still expect the vertical strokes in any character to be heavier than the horizontal ones because that was the effect produced by holding a flat-tipped pen to the paper at a 35- or 40-degree angle. Serifs, the little horizontal bars crossing letter stems, derive from the motion of the pen as it slid into and out of vertical strokes.

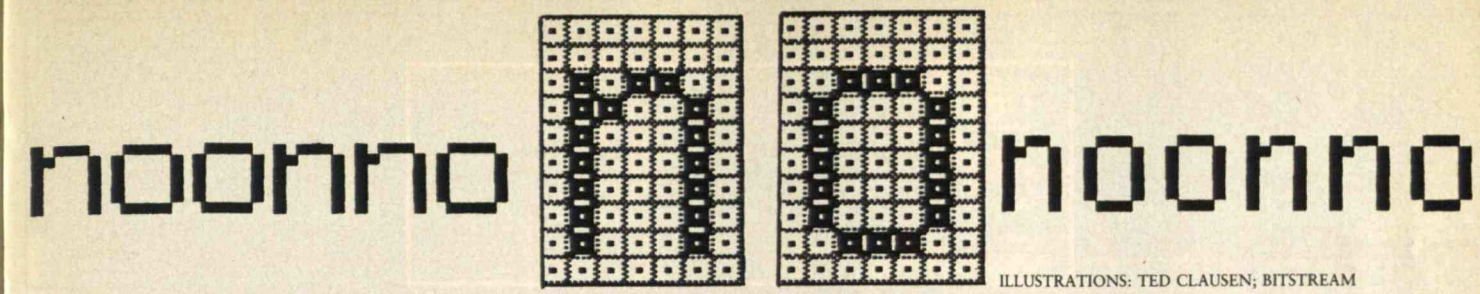
In addition to meeting readers' historical expectations, letterforms must appear consistent. Readers expect an even baseline and x height (the height of a lowercase *x*), as well as similarity in the curves, arches, and other details repeated among characters. Sometimes variations must be introduced to maintain the illusion of consistency. For example, a lowercase *o* must be about 10 percent taller than a lowercase *z* to appear the same height. At the same time, round shapes such as the *o* must be easy to distinguish from diagonal shapes such as the lowercase *v* and rectangular shapes such as the lowercase *n*.

The readability of a typeface depends on "rhythm." Rhythm is "the visual relation of the spaces inside the characters to the spaces between them," says type designer Ted Clausen. If a typeface is well designed, the variations in rhythm—the different ways characters shape the white spaces of words—permit us to grasp whole words at a time. Poor design causes readers to stumble, stop, and reread.

Early printers found it difficult to emulate the fluidity of the scribe's writing. In the letterpress process that these printers used, each character had to be engraved on a rectangle of metal. This engraving was filled with a hot alloy which, when cooled, formed the character. The characters were arranged by hand, line by line, and bound into a text frame. The frame was inked and pressed onto the page.

Before they could design aesthetically pleasing characters, the printers had to solve several technical problems. To ap-





ILLUSTRATIONS: TED CLAUSEN; BITSTREAM

proximate the flexible and subtle spacing of handwriting, each font—the set of engravings from which a given typeface was made—had to include engravings of letter combinations as well as the basic alphabet. The Gutenberg Bible required a font of more than 250 characters and combinations. Some combinations such as *ff* and *fi* were made on a single rectangle. Others had to be "kerned," or joined together, by hand. Designers also had to learn to compensate for the type's tendency to wear and the ink's propensity to spread.

Ironically, many designers today believe that the beauty of letterpress printing—especially the sharp-relief edge characteristically produced—has never been equaled by subsequent technologies. "We've improved the quality of junk printing," says designer John Schappler, who has worked with every medium yet devised. "But letterpress is still the best way to print type, if it's done well."

However, the goal of printing technology has always been to increase the speed and reduce the cost of producing letterforms. The tension between economics and aesthetics has continued to breed innovation in letterform design.

Technology and Design

From the time of Gutenberg until the late nineteenth century, printing technology changed relatively little. Since then the world of printing has seen rapid change. First came automated letterpress printing. The printer used a typewriter-like apparatus to arrange empty molds of characters, one by one (Monotype) or row by row (Linotype). Then the hot metal was poured in. Monotype and Linotype techniques brought with them rigid sizing constraints. Different versions of each character had to measure the same width to fit into the same rectangle as standard Roman type. Bold characters had to be squeezed, and italic characters had to be aligned at varying slants.

In a later technique, photocomposition, also known as "cold type," a negative of the character was mounted on glass or film. The character was projected onto photosensitive paper or film, which was photographically developed. This process dramatically increased the speed and lowered the costs of typesetting. However, type designers encountered problems in adapting metal typefaces to the new medium. Since the new technology did not cause ink to spread, the old letterforms came out "oversharpened, weak, and vigorless," in the words of type designer Hermann Zapf. On the other hand, photocomposition offered much greater flexibility in spacing. Since type no longer had to be mounted on rectangles, character pairs could be spaced more closely, bold type could be wide again, and italic type could have a consistent slant.

For designers, the greatest advantage of photocomposition was also its greatest curse. In the past, it had been necessary to cut a whole new font for every point size, but with the new technology characters were enlarged photographically. Designers could no longer make smaller point sizes more readable by widening the characters, increasing their x height, and making them heavier. However, the speed and low cost of the new technology outweighed these aesthetic considerations.

Craftsmanship in the Computer Age

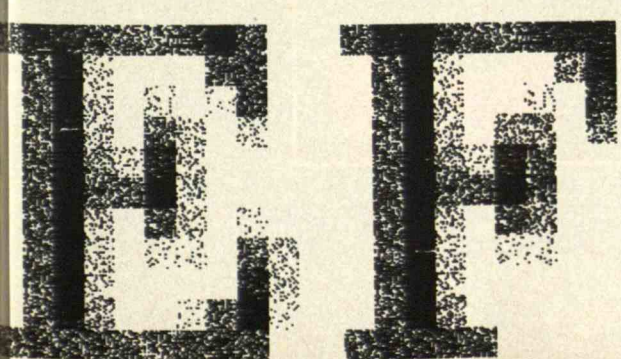
To form a digital letter from dots, as a dot-matrix or laser printer does, you could first draw an outline of the letter on fine graph paper. Then you could fill in the squares—or "pixels" (picture elements)—that either touch or fall inside the outline. Where the outline was curved or diagonal, the digital letter would have stair steps, which designers call "jaggies." The smaller the pixels, the higher the resolution, and the less objectionable the jaggies.

Resolution is usually measured in dots per inch (dpi), the number of pixels per inch of height, or lines per inch (lpi), the number of lines per inch of height. The two measures are equivalent, but designers often prefer to use lpi for equipment such as the high-resolution CRT phototypesetter, which arranges dots in lines.

High-resolution digital typesetting equipment, using 1,200 or more lpi, so nearly approximates the ideal analog outline of letters that it looks as smooth and sharp as photocomposition and offers other virtues as well. It permits nearly unlimited variation in letter size and very fine gradations of spacing, and it achieves a more consistent degree of blackness.

At lower resolutions, many of these advantages are lost. Most video screens have a resolution of 72 to 78 dpi, and many dot-matrix printers have just as low a resolution. As the resolution decreases, the jaggies become larger, and there is what Clausen calls "a critical loss of information." It becomes harder for the reader to differentiate the basic round, rectangular, and diagonal forms of letters. The fine distinctions between serifs and stems, and between thick and thin strokes, disappear.

The screens of most personal computers (PCs) have a 7-by-9 dot matrix in which each letter must fit, including the tail of a *y* and the stem of a *b*. The old Apple IIs were even worse, confining the alphabet to a 5-by-7 pixel grid. To compound the problems designers face, not only do different screens offer different resolutions, but the pixels themselves have different shapes. The IBM color PC, which many



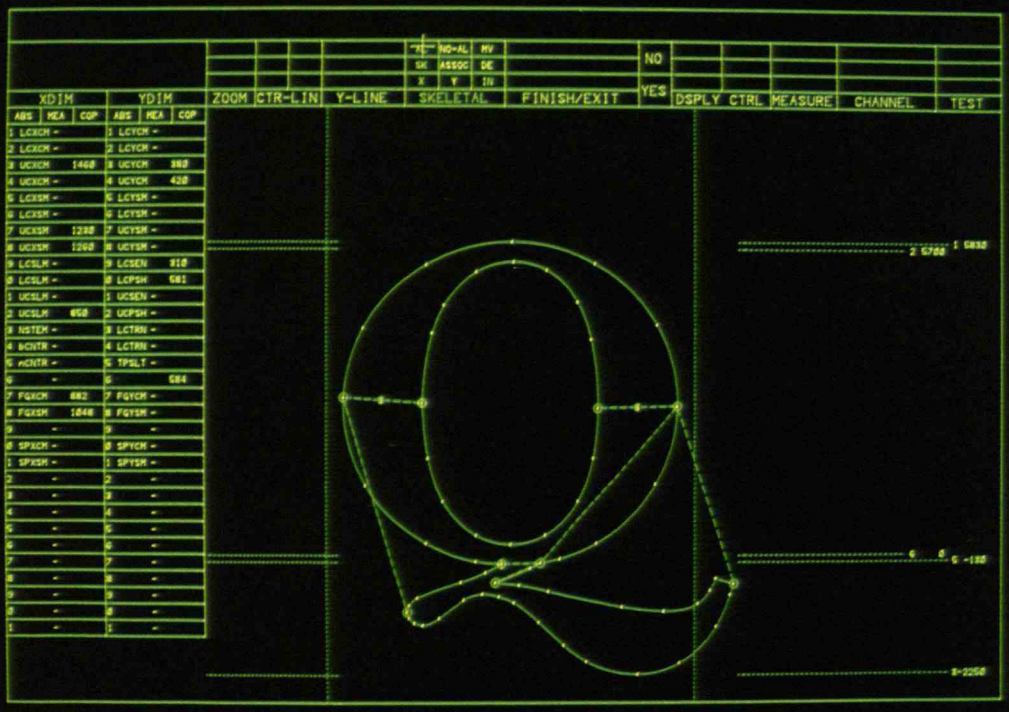
Great care is required in creating good digital letterforms at low resolutions—when few dots, or pixels, are available.

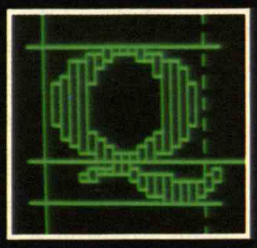
Above are actual designer "sketches" of letters for a video screen. Left: Excessive space between letters causes words to become "unglued." Center: The imbalance of too much space inside letters and too little space between them inhibits reading.

Right: Balancing the spaces within letters with the spaces between them creates a readable "rhythm."

Below left: "Gray-scaled" letterforms are designed for video screens on which each pixel can be adjusted to several different shades. At actual scale the gradual transition from black to white smooths the "jaggies," or stair steps, of digital letters.

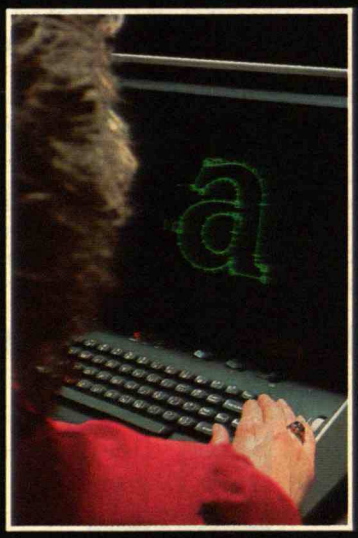






In "outline encoding" the computer stores the outlines of letters and certain other parameters, as displayed for the *Q* on the video screen above. With this information the computer can automatically generate bitmaps—patterns of dots or lines—to form digital letters of different sizes and resolutions. Top photos: Coordinates of points on the outline of traditional analog letters are read into the computer. Right: A designer refines an outline.

After the *Q* has been translated into the right format for the outline-encoding system (above), a program generates bitmaps (left). The designer can refine the outline to improve bitmaps, especially for small sizes and low resolutions.



PHOTOGRAPHS: COMPUGRAPHIC CORPORATION

designers abhor, uses rectangular pixels instead of square ones in an 8-by-8 grid.

Digital letterforms are most commonly stored in a "bitmap," a series of numbers describing which pixels to turn on or off. Every time a computer needs to form a letter on a video screen or printer, it calls up the bitmap from memory. To translate an analog letterform automatically into a bitmap, a camera can scan the letterform and approximate it as a pattern of dots.

However, low-resolution bitmaps generally require editing by a skilled designer, who moves a pixel here and a pixel there to produce a more consistent, legible typeface. This requires numerous subtle decisions. The designer might have to choose between a stem that is too thick at two pixels and too spindly at one, between a one-pixel serif and none at all, between an *i* dotted too high or too low. "At the lowest resolutions, each pixel is crucial," says designer Charles Bigelow, and he warns against falling into a "numerological trance": "Counting stair steps, making sure stem weights are precisely consistent, can make a typeface monotonous and distort the underlying idea." Bigelow believes that for typefaces using up to about 24 lines per x height, the best letterform designs should be created from scratch, not simplified from more complex designs.

Clausen concurs. To construct bitmaps for low-resolution designs, he draws each character by moving pixels on a computer screen. He starts with the lowercase *n* and *o*. The underlying shapes of these letters—rectangle and circle—represent the basic design components of most of the letters we read. After several *o*'s and *n*'s are ready, he tries out combinations—*ooo*, *ono*, *non*, and so forth—to adjust the spacing and establish the rhythm. Working from these key characters, he designs the lowercase alphabet. Then he goes on to capital letters and starts the process over, this time working with *O* and *H*.

Even when a designer has produced an entire font—master bitmaps for a particular size and style of type—it cannot be automatically scaled up or down with good results. Suppose, for example, you have a bitmap to display an *o* that is 10 pixels high and you want a bitmap to display the same letter 20 pixels high. If you simply blow up the 10-pixel bitmap, the jaggies become larger and cruder.

Most personal and office computers exhibit this problem, since they do not have enough memory to store a font of bitmaps for every type size. The screen display of the Apple Macintosh is a case in point, says Susan Kare, who is in charge of the Macintosh's typography. The Macintosh broke new ground by offering a range of type sizes, with proportional spacing (allowing *w*'s and *m*'s to be wider than *i*'s and *l*'s). But often the same font is simply blown up to make the larger sizes.

Cheaper by Computer

Although most personal and office computers store bitmaps, programmers have developed another method for producing digital letters, to save memory and designers' time. In "outline encoding," as the method is called, the computer stores the outlines of letters and certain other parameters, from which it can generate bitmaps of different sizes and resolutions. Outline encoding requires less memory than bitmap storage but more processing power. The high-resolution equipment in most professional typehouses uses outline encoding. But the method has been more difficult to apply at lower resolutions.

Using a computer-aided design (CAD) process, Compugraphic produces outlines for its own medium-resolution laser printers, as well as for other manufacturers' video screens and printing equipment. The designer starts with an analog font of large letters in a particular typeface—say Times Roman—drawn on plastic film. The coordinates of numerous points on the outlines of the letters are read into the computer, and Ikarus, a popular outline-encoding system, translates this information into its own format. For the outline of any letter—say an *R*—Ikarus specifies selected points and the curves and lines connecting them. The designer can display the points, lines, and curves on the screen; the coordinates of the points and formulas for the curves and lines are stored in memory.

Another program can translate this Times Roman *R* outline into bitmaps for digital Times Roman *R*s of different sizes, weights, and resolutions. The designer can display the digital *R*s on a video screen or print them on paper, and can modify the outline to improve the bitmaps, particularly for small sizes and low resolutions. Later, when the designer moves on to other letters, the CAD program ensures that

Continued on page 79

Top to bottom: An analog *n* has been randomly "filled" with pixels. A program has adjusted the image to give the stems even weight. A designer has edited the bitmap to refine the letterform. Alternate pixels are omitted; a laser printer will blur the sawtooth edge, giving the effect of a half-line thickness.

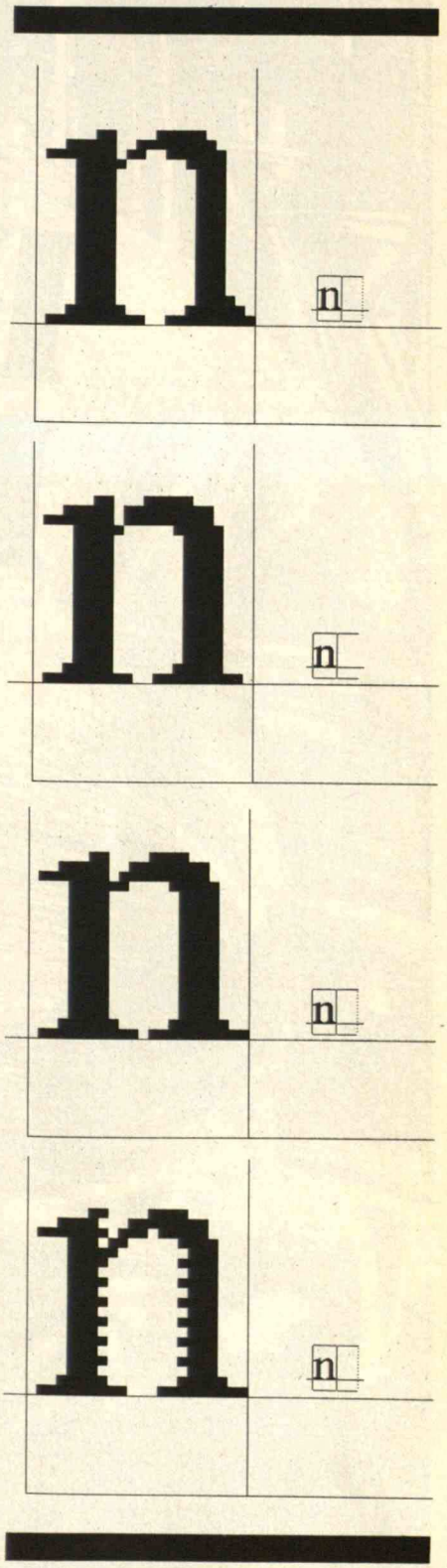


ILLUSTRATION: BITSTREAM



Eugene Yelchin 86

Universities, Professors, and Patents: A Continuing Controversy

BY CHARLES WEINER

Now that academic biology has reached the payoff point, a new status quo permits and even encourages patenting and commercializing research results. Most university administrators and many biologists believe that patents can help strengthen their institutions' financial security, provide incentives for individual faculty members, and hasten the transfer of knowledge from the university to the public. As a result, many universities are aggressively pursuing patents on applications made possible by genetic engineering, cell fusion, and other fruitful areas of contemporary biology.

To allay fears that such commercial behavior might harm the academic community, advocates often point out that patenting of academic research is widely accepted in many fields, and that the results are generally positive. However, a detailed examination of how academic scientists have dealt with patents throughout the twentieth century—based primarily on archival materials at a number of institutions—reveals that this has not always been the case. Academic scientists have long debated the merits of patenting, and many of them have remained leery of the idea.

Universities that have engaged in patenting have often seen their public image tarnished and the credibility of their faculty questioned. They have also incurred huge legal costs defending their patents from infringement. Moreover, the exchange of scientific information has been restricted as universities and scientists have attempted to protect patentable research results. These problems still plague the patent system, particularly in biology. Past and contemporary events show that the commercialization of academic biomedical research can create conflicts of interest that seriously erode public trust. These drawbacks are high prices to pay, especially since patents generally have not yielded significant income for universities.

The Traditional View of Patenting

The original aim of the patent system was to encourage invention by rewarding the individual inventor. Inventors take out patents in the hope that they will yield financial returns. The patent grants the inventor a 17-year monopoly that allows him or her to exclude all others from making, using, or selling the invention. Of course, patent owners may sell rights to those willing to pay licensing fees for the privilege of using the invention. When patenting occurs at universities, the inventor and the institution

Historical evidence reveals that patenting by universities can erode public trust in academia. This problem is growing as universities aggressively pursue patents in biotechnology.

ILLUSTRATION: EUGENE YELCHIN

usually split the royalties according to a predetermined arrangement.

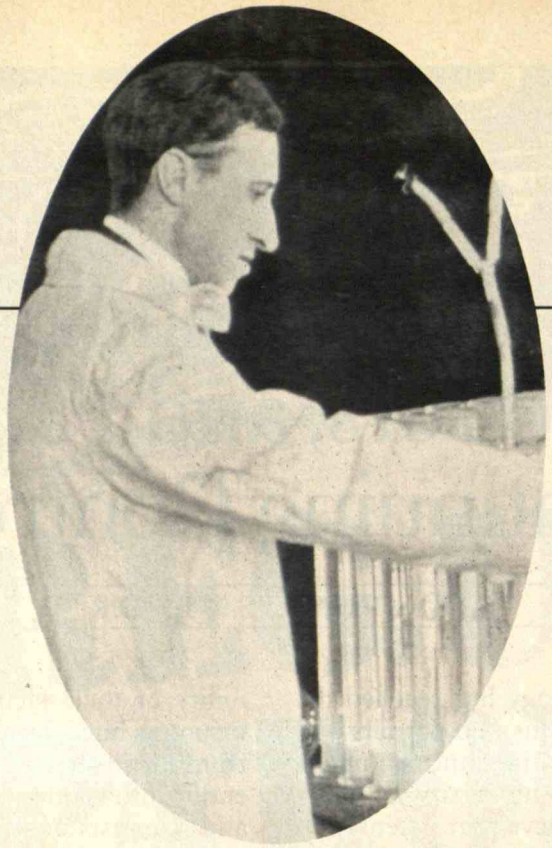
In the early part of this century, academic scientists rarely took out patents because there was a general belief that this would corrupt the traditional nature and role of the university. This view was especially strong in the field of biomedicine, because the goal of scientists who pursued such research was to understand, prevent, and cure disease. Many scientists argued that the academic tradition of making medical discoveries freely available to all did not mesh with the patent system's emphasis on monopoly and making money. They did not wish to "profit from the public ills." Critics claimed that patenting altered scientists' allegiances and aims, skewed research priorities toward profitmaking, restricted the exchange of scientific information, and provoked professional jealousies.

Proponents argued that patenting could be an efficient way to facilitate the flow of knowledge and new processes into socially useful products. Some argued that without patenting, discoveries made by university scientists would simply be ignored. Others believed that licensing arrangements could force manufacturers to adhere to quality and safety standards that the government was not then requiring. Patenting could also generate new sources of income to be used to strengthen academic research. Finally, proponents maintained that the possibility of financial reward and public recognition could motivate scientists to push basic research to new heights.

A letter written in 1917 by the renowned biologist Jacques Loeb, then at the Rockefeller Institute for Medical Research in New York, testifies to the uneasiness the issue of patenting raised among university scientists. Loeb expressed deep concern about T. Brailsford Robertson's decision to patent tethelin, a substance extracted from the pituitary gland in the brain and thought to promote growth. Robertson, a former student of Loeb's, had succeeded him as head of the biochemistry department at the University of California at Berkeley. Writing to a mutual colleague, Loeb said:

"When I spoke to an influential person . . . suggesting Robertson for that chair [in physiology at Johns Hopkins], I was told that Robertson had hurt himself by taking a patent on tethelin. . . . I told them that I knew nothing about it but that if Robertson had patented it, it probably was done chiefly to prevent foreign drug firms from exploiting their patients [sic]. If the rumor is unfounded, I wish you would let me know at once so that I can contradict it. I do not think that Robertson cares for the chair but I do not want such a rumor to spread if it is false. If it should be true that Robertson has patented tethelin. . . . I think it would be fair to tell Robertson how strong the prejudice against such things is in the east, and perhaps to put him on guard for future action."

But Robertson had a larger scheme in mind. In September 1917, he donated his patent rights to the University of California. Profits resulting from the discovery were to be put into an endowment fund, and the income used to establish an institute for medical research at the university, in which Robertson would play a major role. The lead article of the October 19, 1917, issue of *Science* hailed the agreement on the tethelin patent as "a new development in the relationship of science to the industries, and



When T. Brailsford Robertson patented tethalin, a substance thought to promote growth, and donated the patent rights to the University of California, one prominent biologist warned that "pure science will be doomed" if universities begin handling patents.

CHARLES WEINER is professor of history of science and technology in the Program in Science, Technology, and Society at M.I.T. He is now working with research associate Philip Alexander on a historical study of university patenting in the field of biomedicine.

of scientific investigators to the institutions employing them." In a statement providing a rationale for his approach, Robertson noted the dangers of identifying an individual professor and a laboratory with a purely business enterprise. But he believed that his plan would circumvent such difficulties.

Loeb did not approve of the scheme even with these precautions, and in another letter to a mutual colleague he pointed out that Robertson's scheme would create two types of professors: "desirable" ones who might add to the material welfare of the institution by taking out patents, and "worthless specimens who are unable to take out patents. ... The place for patents must be the institutions for applied science, but if the institutions for pure science go into the handling of patents I am afraid pure science will be doomed." Although Loeb recognized that patents could be used to control product quality and increase research funds, he remained convinced that the disadvantages outweighed the advantages.

The University of California's efforts to turn the profits from tethelin into support for further academic research were unsuccessful. The university did give the H.K. Mulford Co. a five-year exclusive license to produce the substance. But although further research turned up some uses for tethelin in treating burns, it did not confirm the original hopes that the substance might promote growth or be useful in understanding cancer. References to tethelin soon disappeared from the scientific literature. In 1923, by the end of Mulford's five-year contract, the university's royalties on sales of tethelin amounted to only $272.47. Needless to say, neither the company nor the university was interested in renewing the license. There is no evidence that the research institute Robertson had envisioned was ever established.



In the early 1920s, Harry Steenbock patented a process that enhanced vitamin D in food. To manage his patents, the University of Wisconsin set up a nonprofit institution known as WARF, which was financially successful but highly controversial.

This situation was not atypical: patenting by university scientists rarely paid off. Moreover, when a patent did bring in substantial funds, it created many problems. This was the case with the patent taken out by Harry Steenbock of the University of Wisconsin and administered by the Wisconsin Alumni Research Foundation (WARF).

Many scientists today cite WARF as an important historical precedent and a successful example of the way a university should handle a patent. If success is measured in terms of the income that a patent generates, then perhaps that assessment is accurate. However, a different story emerges if we look at the effects on the university's public image and role in the 1930s and 1940s.

The Controversy over WARF

In the early 1920s, Harry Steenbock, a biochemist at the University of Wisconsin, developed a process that enhanced the concentration of vitamin D in food and pharmaceutical products. The technique involved irradiation with ultraviolet light. Steenbock knew that his process would enable manufacturers of what were then relatively new products—oleomargarine and infant formula—to enhance their nutritional quality and thus compete more successfully with natural dairy products. He realized that this would pose a threat to the dairy industry, a longtime supporter of the university and an influential lobbyist in the Wisconsin state legislature. When Steenbock filed patent applications in 1924, food manufacturers expressed keen interest in buying the patent rights, with Quaker Oats, for example, offering him close to $1 million. But he refused to sell and suggested instead that a nonprofit institution

PHOTO: UNIVERSITY OF WISCONSIN

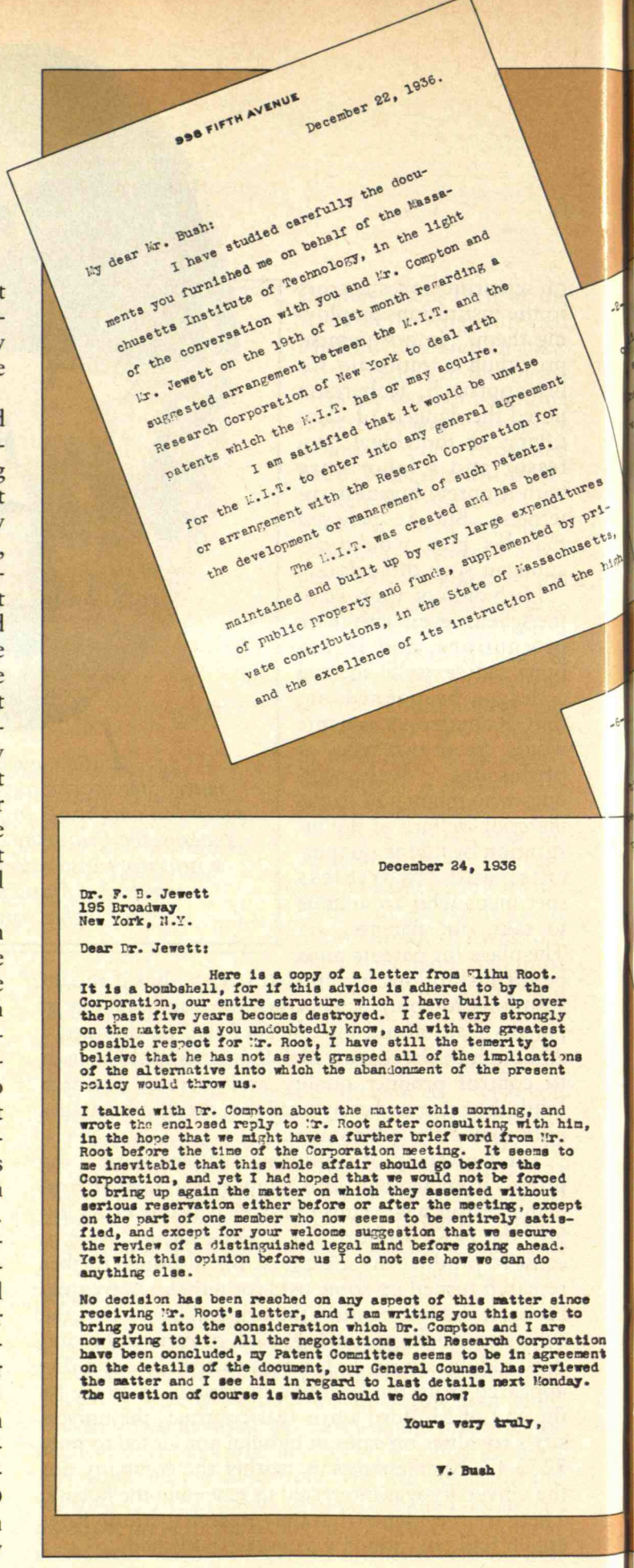
such as the university manage the patents "to protect the interest of the public." He argued that the university could also use the patent to protect the dairy interests, and that licensing royalties could provide substantial support for research.

The university's administration was concerned about the ethics of entering the patent area. Steenbock therefore explored other ways of administering the patents, such as setting up a foundation that would be allied to the university but operationally independent. He finally persuaded H.L. Russell, dean of the College of Agriculture, and Charles Slichter, dean of the graduate school, to lend their support in setting up such a foundation. The deans raised money for the foundation and tried to convince the state board of regents, which made policy for the state university, to establish it. The deans' argument was that a program of patent management was essential to protect the public from exploitation by food and pharmaceutical companies, who might claim that they had increased vitamin levels in their products when in fact they had not. The regents gave their reluctant endorsement when it was clear that the university would have no responsibility, financial or otherwise, for the foundation.

Their approval provoked opposition from within and outside the university. Faculty members of the College of Agriculture expressed concern that the plan might divert the focus of university research from aiding farmers to making money through patentable ideas. The Milwaukee press published stinging editorials holding that scientists have no right to patent discoveries financed by public funds, and that awarding patents to a private foundation only compounded the injury to the public. Some researchers at other universities argued that it was wrong in principle to patent the results of scientific discoveries.

Despite such criticism, the foundation was incorporated on November 5, 1925, and WARF supporters went on the counteroffensive. Dean Russell of the School of Agriculture attacked the critics for their naivete, arguing that a policy of donating patent rights to the public only opened the door for misuse and fraud.

In July 1927 WARF signed its first contract—an exclusive license for Quaker Oats to use the irradiation process in cereal foods. Several firms were licensed in 1929 to market concentrated vitamin D oil. The foundation reaped about $1,000 a day in royalties from these and other contracts, and by



December 22, 1936.

...FIFTH AVENUE

My dear Mr. Bush:

I have studied carefully the documents you furnished me on behalf of the Massachusetts Institute of Technology, in the light of the conversation with you and Mr. Compton and Mr. Jewett on the 19th of last month regarding a suggested arrangement between the M.I.T. and the Research Corporation of New York to deal with patents which the M.I.T. has or may acquire.

I am satisfied that it would be unwise for the M.I.T. to enter into any general agreement or arrangement with the Research Corporation for the development or management of such patents.

The M.I.T. was created and has been maintained and built up by very large expenditures of public property and funds, supplemented by private contributions, in the State of Massachusetts, and the excellence of its instruction and the high

December 24, 1936

Dr. F. B. Jewett
195 Broadway
New York, N.Y.

Dear Dr. Jewett:

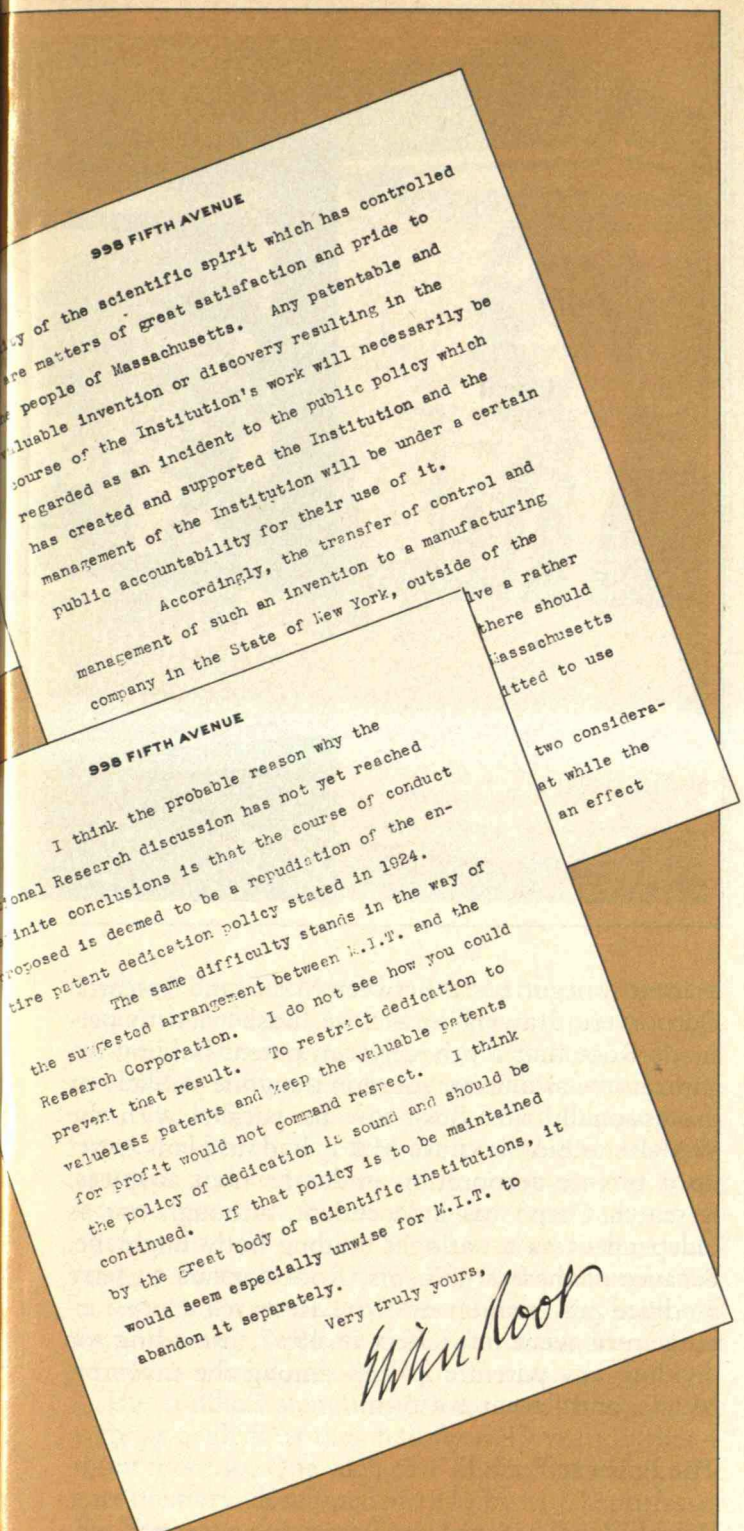
Here is a copy of a letter from Elihu Root. It is a bombshell, for if this advice is adhered to by the Corporation, our entire structure which I have built up over the past five years becomes destroyed. I feel very strongly on the matter as you undoubtedly know, and with the greatest possible respect for Mr. Root, I have still the temerity to believe that he has not as yet grasped all of the implications of the alternative into which the abandonment of the present policy would throw us.

I talked with Dr. Compton about the matter this morning, and wrote the enclosed reply to Mr. Root after consulting with him, in the hope that we might have a further brief word from Mr. Root before the time of the Corporation meeting. It seems to me inevitable that this whole affair should go before the Corporation, and yet I had hoped that we would not be forced to bring up again the matter on which they assented without serious reservation either before or after the meeting, except on the part of one member who now seems to be entirely satisfied, and except for your welcome suggestion that we secure the review of a distinguished legal mind before going ahead. Yet with this opinion before us I do not see how we can do anything else.

No decision has been reached on any aspect of this matter since receiving Mr. Root's letter, and I am writing you this note to bring you into the consideration which Dr. Compton and I are now giving to it. All the negotiations with Research Corporation have been concluded, my Patent Committee seems to be in agreement on the details of the document, our General Counsel has reviewed the matter and I see him in regard to last details next Monday. The question of course is what should we do now?

Yours very truly,

V. Bush



998 FIFTH AVENUE

...y of the scientific spirit which has controlled
...re matters of great satisfaction and pride to
... people of Massachusetts. Any patentable and
...luable invention or discovery resulting in the
...ourse of the Institution's work will necessarily be
regarded as an incident to the public policy which
has created and supported the Institution and the
management of the Institution will be under a certain
public accountability for their use of it.
Accordingly, the transfer of control and
management of such an invention to a manufacturing
company in the State of New York, outside of the
...ve a rather
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...an effect

998 FIFTH AVENUE

I think the probable reason why the
...onal Research discussion has not yet reached
...inite conclusions is that the course of conduct
...roposed is deemed to be a repudiation of the en-
...tire patent dedication policy stated in 1924.
The same difficulty stands in the way of
the suggested arrangement between M.I.T. and the
Research Corporation. I do not see how you could
prevent that result. To restrict dedication to
valueless patents and keep the valuable patents
for profit would not command respect. I think
the policy of dedication is sound and should be
continued. If that policy is to be maintained
by the great body of scientific institutions, it
would seem especially unwise for M.I.T. to
abandon it separately.

Very truly yours,

Elihu Root

Faced with the Depression, many universities began to establish patent policies and search for new funding sources. In 1936, Vannevar Bush, dean of engineering at M.I.T., persuaded the Institute to hand over patent management to the nonprofit Research Corp. But at the last minute Elihu Root, a highly respected member of the M.I.T. Corporation, voiced serious reservations (above). In a letter to Frank Jewett, head of Bell Labs and a member of the M.I.T. Corporation, Bush called Root's objections a "bombshell" (left). However, Bush managed to change Root's mind and the plan went into effect.

DOCUMENTS: LIBRARY OF CONGRESS

1931 WARF had amassed a sizable endowment of $400,000. When the press learned that the university was accumulating the patent funds rather than spending them on research, it accused the foundation of collaborating with big business to exploit the public, and of using royalty income to purchase corporate stocks and build enormous capital reserves. Russell responded by saying that the endowment had to be built up significantly before the foundation could consider using royalties for university activities. However, within the year WARF had established a program of doctoral fellowships. In 1932, at the height of the Depression, the foundation awarded a grant of more than a quarter of a million dollars to the university and donated a chair of wildlife management to the College of Agriculture. The biochemistry department eventually became the largest graduate biochemistry program in the United States through WARF grants and fellowships, and other departments at the university also benefited.

A Damaged Public Image

Despite this apparent munificence, WARF's public image continued to decline because it managed its patents aggressively, much as a business would. Public-health professionals argued that WARF's monopolistic control of the patent—and the licensing fee—had led to higher prices for vitamin-D-irradiated milk. At a National Research Council conference on patent issues in 1935, a leading Johns Hopkins University scientist cited WARF as a perfect example of the "unfortunate tendency . . . exhibited by our universities in attempting to make the results of work done in their laboratories contribute to their support." He saw the aggressive advertising campaign for products covered by WARF's patents, its commercial "exploitation" of basic research, and its "taxation" of products that improve the public health as "objectionable" developments.

WARF's image was further damaged in 1937 when the foundation brought a series of suits against companies for infringing on its patents. These complex cases resulted in costly, sometimes ugly court battles that persisted over the next ten years. The suits led the press in several states to call for a probe of WARF's finances, and the government began an antitrust investigation against the foundation. The Justice Department reported in 1943 that WARF had suppressed the use of other vitamin-enhancement

processes, participated in an international cartel to limit world competition, and collaborated to maintain artificially high prices for products with irradiated vitamin D.

WARF argued that far from operating as a "drug combine," it was acting as a not-for-profit foundation to protect the public, that state and federal codes rather than royalty charges had forced up the cost of products irradiated to enhance vitamin D, and that the patents stimulated widespread use of the process and secured funds for other valuable research. After several adverse court decisions and continuing criticism from the public and the government, however, the foundation was obliged to revise some of its strategies.

Meanwhile, university scientists and administrators, faced with the Depression in the 1930s, were still hoping that patents could yield funds for research. Several organizations decided to reassess the patenting process. The American Association for the Advancement of Science, the National Research Council, and the American Medical Association explored ways to reduce or reconcile possible conflicts over patents. The latter two organizations proposed that patents be assigned to "inter-institutional commissions" or "centralized patent-holding bodies," overseen by professional societies or quasi-governmental agencies, rather than to universities. No consensus was reached, however. Despite the evident problems, many educational institutions were beginning to establish firm patent policies. The Depression was making it more acceptable for universities to explore new sources of funding.

In 1936 Vannevar Bush, dean of engineering and vice-president at M.I.T., persuaded the M.I.T. Corporation to hand over the management and promotion of the Institute's patents to Research Corp. of New York, a nonprofit organization that functioned as a liaison between universities and industry. However, the M.I.T. Corporation soon reconsidered its position because Elihu Root, a New York lawyer and a highly respected member of the corporation, favored the National Research Council's proposal to set up a national holding body to manage patents that would be dedicated to the public. Root thought that the adverse results of the University of Wisconsin's patent-management scheme showed the dangers of giving responsibility to privately run agencies.

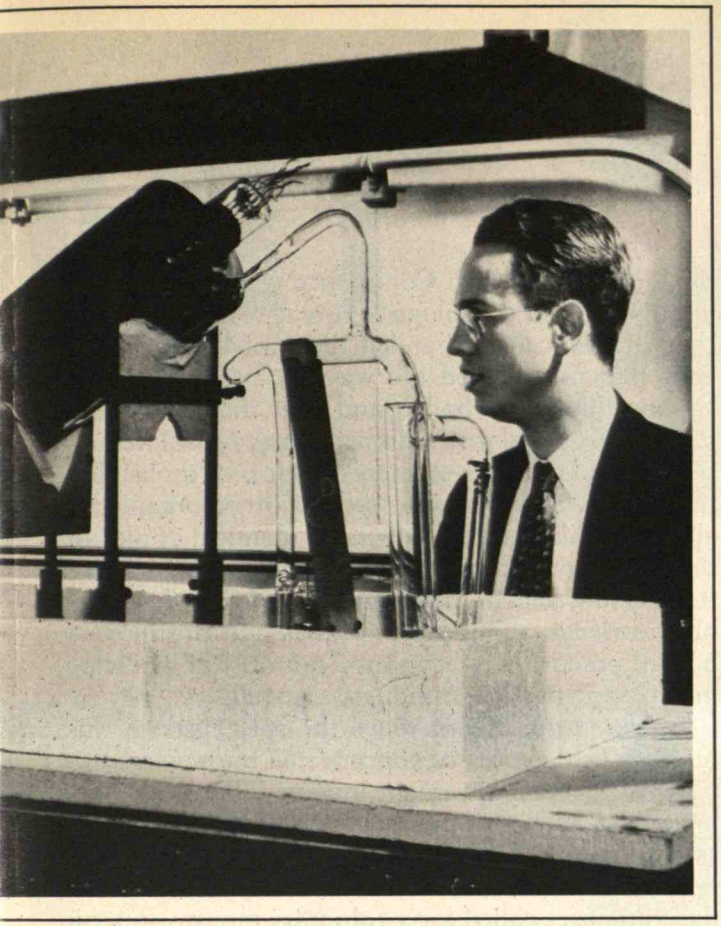
Root voiced his severe opposition to the plan just as lengthy negotiations between M.I.T. and Research Corp. were drawing to a close. Bush tried to persuade Root that a privately run patent-holding organizaton was a better solution than one publicly or professionally run. Bush saw no parallel with the WARF situation because M.I.T. had no plans to set up a private corporation under its own auspices. Research Corp. was independent, although not as independent as a national holding body might be. Because of these arguments, Root appears to have modified his opinion and the Research Corp. arrangement went into effect in 1937, providing for dividing any patent royalties among the inventor, M.I.T., and Research Corp.



In 1949, M.I.T. Professor Jay Forrester invented the magnetic core memory, an information-storage system that made commercial computers feasible. M.I.T. patented the core memory, and it became the university's most lucrative patent. However, the patent also provoked expensive legal battles with RCA, IBM, and other companies. Here, Forrester (near right) looks at a vacuum tube memory, a precursor to his invention.

The Postwar Period

World War II brought important changes to the major American research universities. After the war, campuses that had bustled with R&D devoted to the war effort received a large influx of federal funding, and this support began to play a major role in their financial affairs. Government funds for campus research and for the "indirect costs," or overhead, associated with grants and contracts soon provided much larger and more predictable financial returns to universities than they had gained from patents before the war. Yet as the amount of government-



sponsored research grew, more and more universities established formal patent policies, in part to cope with regulations requiring government ownership of inventions from research supported by federal agencies. These rights could be waived by the appropriate agency, with royalty-free use provided to the government and restrictions on how universities could license patents. Policies varied from agency to agency. In 1934, only 18 universities were developing patents, but by 1947, 200 had a direct interest in patents. At least 20 of these institutions managed them through separate research foundations, most of which were controlled by universities.

The conflicts stemming from these arrangements were as evident as they had been 40 years earlier—if not more so. One such case involved the magnetic core memory, developed in 1949 by M.I.T. professor Jay Forrester as part of a federally funded project. This information-storage system consisted of rectangular arrays of minute magnetic cores strung on wires, through which information was transmitted to electronic circuits in a computer. By providing far greater speed and reliability than the electrostatic storage tubes then in use, the magnetic core memory made commercial computers feasible. Research Corp.'s filing of patent applications on Forrester's invention in May 1951 led to a tense power struggle and complex litigation between M.I.T. and various parties. For example, RCA contended that one of its researchers, who had previously filed a patent application on a magnetic memory system, had a more valid claim to inventorship. Disagreements between M.I.T. and Research Corp. about how to defend and license the potentially lucrative patent contributed to the termination in 1963 of their longstanding arrangement. M.I.T. then began elaborate detective work, using past telephone bills and lists of conference attendees, to try to prove that the RCA inventor had acquired knowledge of the core memory through "leaks" from the M.I.T. community.

In 1964, after eight years of controversy, the court settlement established Forrester's position as inventor of the core memory, and M.I.T. and RCA resolved their remaining differences out of court. In return for a commitment that RCA would press no further priority claims, M.I.T. signed an agreement granting both royalty-free and royalty-bearing licenses to RCA. However, M.I.T.'s litigation with other firms continued for several years. While the core memory provided M.I.T. with its largest source of patent income—$19 million from 1964 to 1978 compared with less than $2 million from all other patents between 1932 and 1963—the long-term legal struggles were expensive and created a public image of the university as a business competitor. Such legal controversies also provoked concern that universities were diverting their resources from basic research to product development and management.

The Melman Report

In 1958 Seymour Melman, professor of industrial engineering at Columbia University, completed a study for the U.S. Senate Subcommittee on Patents, Trademarks, and Copyrights on the impact of the patent system on research. Melman interviewed scientists, engineers, and research directors at universities and major companies such as Ford, DuPont, AT&T, and Standard Oil. His findings led him to conclude that the patent system was falling short of its constitutional mandate "to promote science and the useful arts."

Melman's view was that identifying an "inventor" had become increasingly difficult because of the division of labor and collaboration among specialists in both basic and applied research. Furthermore, he felt that the system perpetuated a "fearful array of struggles" over property rights that proved to be "a

PHOTO: MIT MUSEUM

restraint rather than an impetus" to further research. Patent umbrellas, reinforced by costly and lengthy legal proceedings, afforded companies access to certain research while preventing their competitors from pursuing research in the same area. Melman also felt that there was a growing danger that universities were transferring their efforts from basic research to developing inventions that could prove more lucrative. Academic scientists at a number of institutions expressed their dissatisfaction with this situation quite freely to Melman, in part, he speculated, because it was a relative novelty for universities to stray from the goal of pursuing knowledge for its own sake. Patenting was an extremely sensitive issue that caused major rifts among faculty members. One professor at a major institution became so frustrated that he accused his colleagues of "worshipping the golden calf," and the university officially censured him for doing so.

Melman's final report recommended that the patent system be replaced with one based on non-monetary awards. After he submitted this report to the Senate subcommittee, a "long silence" ensued. It was clear that the subcommittee had expected Melman to offer suggestions on how to improve the system, not on whether to dismantle it. When the committee staff did finally respond, they asked him to modify certain statements. He agreed to make some clarifying changes but refused to touch the conclusion. Eventually he told them to publish the report as it stood or not at all. The committee decided to include a disclaimer stating that the report, though "thoughtful and competent" and a "valuable contribution to the literature," did not imply acceptance or approval by the subcomittee. The report created a brief flurry among patent lawyers, who prepared a rebuttal questioning the accuracy of Melman's report. They maintained the view that the patent system had consistently served as a stimulus to basic science and invention—and would continue to do so if given the chance.

The Academic Biologists

University scientists in the fields that contributed to what we now call molecular biology were largely unconcerned with patent issues. The fifties and sixties were a time of great excitement and expectation for these scientists as they illuminated the structure of DNA and deciphered the genetic code. But not until the Gordon Research Conference on Nucleic Acids in July 1973 did biologists reveal results that not only dramatically expanded their intellectual horizons but also opened the way for practical applications. Biologists had found that they could use newly discovered restriction enzymes to isolate and remove specific gene segments from DNA molecules, recombine them with the DNA of other organisms, and reproduce large numbers of identical copies of the hybrid or recombinant-DNA. These methods of transferring genetic material opened new frontiers of knowledge about life processes and promised a host of practical applications—not only in medicine but in agriculture and industry as well.

At the Gordon conference the specialists in this budding field expressed concern that the new recombinant-DNA research might involve laboratory hazards. This led the National Academy of Sciences to establish a committee to study the problem. In an open letter to the scientific community in July 1974, the committee called for a voluntary moratorium on experiments of greatest potential risk until a conference could be held to assess hazards and devise safeguards. Later, at the Asilomar conference in February 1975, scientists devised a framework for developing safety guidelines for laboratory research. A committee set up by the National Institutes of Health (NIH) later hammered out specific guidelines for researchers with NIH grants.

In November 1974, during the moratorium, Stanford University applied for a patent on the basic recombinant-DNA techniques that made genetic manipulation possible. The university filed the patent, which was intended to generate income for the university, on behalf of Stanley Cohen from Stanford and Herbert Boyer from the University of California at San Francisco. Stanford was able to apply for the patent because it had signed an NIH Institutional Patent Agreement, which transferred NIH's patent rights as sponsoring agency to the university in return for a royalty-free license for the government.

Some scientists and university administrators disagreed with Stanford's and the University of California's decision to patent, voicing Melman's concern that a number of institutions and investigators had contributed to knowledge in the field and that proprietary rights were thus ill-defined. A few felt that recombinant-DNA techniques were "of such a peculiar nature"—because they involved the manipulation of genetic material—that inventors

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FEB/MAR 1986



FLORENCE LUSCOMB '09

A Life of Political Activism

MIT
FEBRUARY/MARCH 1986

ENTERPRISE FORUM: GOING PUBLIC A4
Three ventures, three stories.

MANAGEMENT SKILLS A5
Don't leave home without them.

KEN OLSEN ON DIGITAL A6
If you made the decision, you make it work.

MICROELECTRONICS: REVOLUTION IN BUILDING 29 A11

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ABOUT THE COVER
Florence Luscomb's career as an activist was well established when, as an M.I.T. senior, she took to the streets in 1909 to sell *The Woman's Journal* (see page A14). (Photo: M.I.T. Museum)

COMMENTARY
BY SUSAN LEWIS

National Mood on Divestment Reverberates at M.I.T.

Throughout 1985 and continuing this year, faculty and student groups at colleges across the country have been urging trustees to sell institutional holdings in companies that do business in South Africa. "Divestment," President Paul E. Gray, '54, has said, "has come to be seen as a proxy for opposition to apartheid," South Africa's system of institutionalized racism.

Columbia University is one institution that decided to divest; so did the University of Wisconsin and Michigan State. Brown trustees expected to decide at a February meeting on "what steps the university should take to support those who oppose apartheid." In January, Dartmouth College came through what one journalist termed "an anguished week" that included a 30-hour occupation of the president's office by some 200 faculty and student demonstrators supporting pro-divestment efforts on that campus.

Against this backdrop of intense national activity, the M.I.T. community has been galvanized into a level of political concern rarely seen in recent years, manifested in ways that reflect the unique priorities of this institution.

Demonstrations and a Colloquium

For example, M.I.T. students have joined in demonstrations with their counterparts at other Boston-area colleges, and a noticeable fraction of the graduates at the 1985 Commencement wore red armbands to signify their support for the political aspirations of black South Africans. The number of politically oriented groups on campus, as noted by Undergraduate Association President Brian Moser, '87, has increased from two when he entered as a freshman to about 10 now. Moser says the groups espouse a range of liberal and conservative points of view, but on this issue they joined forces to form a campus Coalition Against Apartheid.

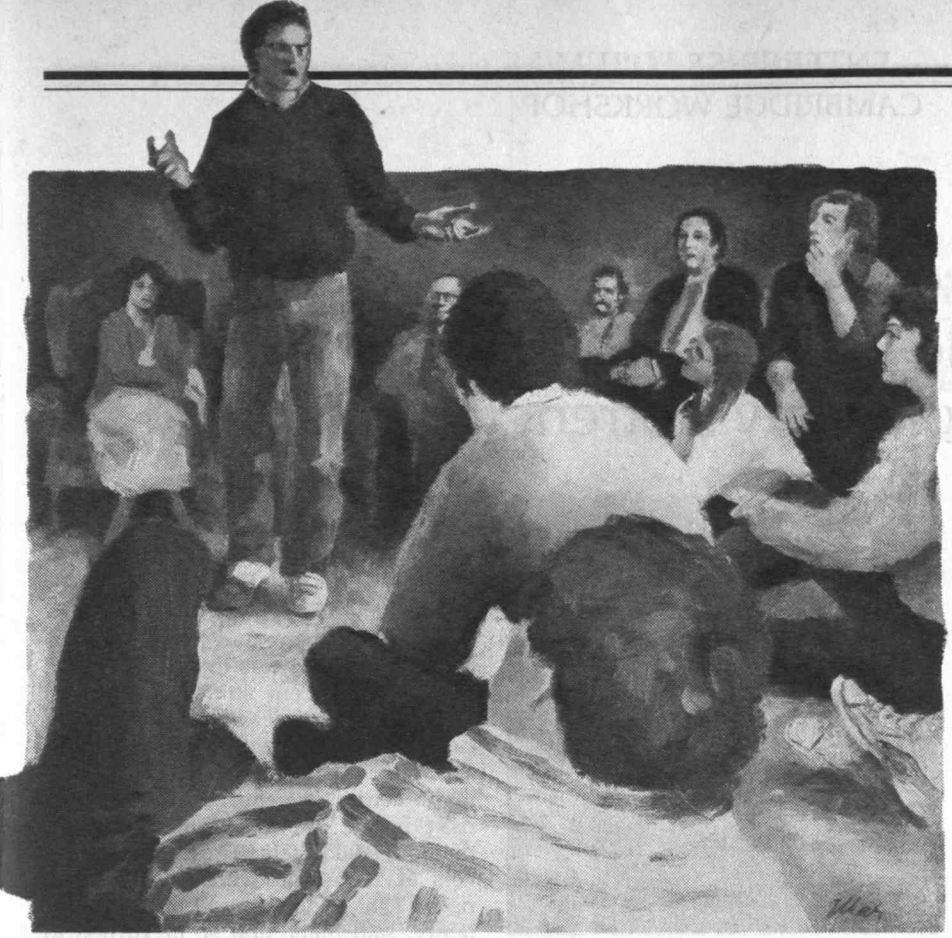
But the real measure of the new weight accorded social and political concerns, and this one in particular, came with the establishment of the Institute Colloquium, sponsored by the Provost's Office. The colloquium is intended primarily as a long-term, large-scale effort to engage faculty and students in discussions of compelling contemporary issues. The first one was held in November; it focused on apartheid and attracted an estimated 800 participants for a variety of events over a two-day period.

In addition to keynote speaker Nthato Motlana, a South African physician who has been a leader against apartheid for 30 years, the colloquium involved American industrialists, legal experts, a member of the State Department, and some 50 faculty members and graduate students as discussion leaders. They represented as diverse a range of opinion as organizers could assemble.

There were large colloquium sessions in Kresge, but what made this occasion extraordinary was the way it took advantage of the central position of residences in M.I.T. student life. At panel discussions, receptions, and meals in the living groups, faculty and guest speakers came into close, informal contact with students. The discussions ranged from the prospect of accelerating violence in South Africa to the personal implications of accepting a job with a company doing business there.

Students responded to the colloquium format and the range of speakers with intense interest. William Jacobsen of the State Department had to cancel an appointment with colloquium chairman Frank Morgan, '74, associate professor of mathematics, because Jacobsen's discussions with students at Next House started at breakfast and extended through lunch. At least one faculty member found that his students were willing to make up a cancelled class on a coming holiday in order to be free to attend the colloquium.

Paul E. Gray, '54, met freely with students over this emotionally charged issue, as the president was both a participant in and observer of colloquium events. While personally abhoring apartheid, Gray has often stated his personal view that divestment is of



questionable efficacy as a means of undermining it. At the same time, divestment puts the universities at political and financial risk. Not surprisingly, this view has been decried by student activists on a number of occasions.

Some faculty members also took exception to the president's position in December, when a resolution urging the Corporation to divest was put on the agenda of a special faculty meeting. At the height of the pre-holiday exams and grading period, close to 200 faculty members turned out to discuss, amend, and ultimately pass a resolution to that effect. (*See the news report on page A8.*)

One-Sided Debate?

More than one person at the faculty meeting reported feeling that the debate was somewhat one-sided. There was a sense that anyone who questioned divestment as an appropriate strategy would be showing ambivalence on the need for reform in South Africa.

But enough faculty members did ask good questions to validate a comment by Columbia President Michael Sovern that "divestment is a complex issue on which decent and reasonable people disagree." Make that decent, reasonable, and well-informed people.

For example, what is the impact of divestment on university income? The best analysis available to M.I.T. Treasurer Glenn Strehle, '58, suggests that South-Africa-free portfolios might earn 1.75 to nearly 10 percent less income over 5 years than unrestricted portfolios. But John Parsons, assistant professor of finance in the Sloan School, believes that there are enough alternative investment opportunities to keep portfolios performing successfully. How does the thoughtful listener form a view?

There is also significant divergence of opinion on whether American investment has improved the income and job training opportunities for black South African workers or whether it has strengthened the white nationalist government. If in fact it does both, which is more important? If universities sell their stocks in South Africa-linked industries, are investors who purchase the stocks less insistent on the dissolution of apartheid? And if American universities dissociate themselves from companies that operate in South Africa, to whom do they go later for support in the task of helping South Africa rebuild an equitable educational, industrial, and social system?

These are not the only questions that may face the Corporation Executive Committee when it considers the faculty resolution at a February meeting. Given its legal responsibility to protect M.I.T.'s income for education and research, the committee will have to consider the impact of any change in investment policy not only on portfolio earnings, but on relations with industries that have been M.I.T. research partners and supporters.

Such financial questions are not the primary concern of the faculty and students. For them, the responsibility is rather to address the intellectual agenda of the Institute. It is particularly significant that faculty and students are moving apartheid closer to the top of that agenda at precisely the same time that great numbers are also involved in revamping M.I.T.'s undergraduate curriculum and the place of the humanities therein.

Alumni can expect to read much in these pages of the *Review* about the thinking behind the coming changes in curriculum. The changes will reflect the conviction that education in this age must produce graduates who are not only technologically sophisticated, but able to apply technology in the service of society. And as Samuel Florman notes elsewhere in this issue (*see page 18*), it will be difficult to find opportunities to broaden an already demanding four-year curriculum to consider social and humanistic questions.

In organizing the colloquium and voting on divestment, however, the faculty are offering a case study to students and their colleagues on why such broadening is immeasurably important. Apartheid is an issue that inextricably winds together ethical, economic, political, historical, legal, even literary dimensions. Divestment questions involve universities in an American political debate, in an international context, on an issue of profound human concern. Yet it remains an arena in which technical expertise is vital—for example, to optimize investment earnings to support education, and to operate international industries in ways that benefit both local laborers and overseas investors. Nowhere, in fact, will such expertise be needed more than in post-apartheid South Africa.

A key message of this case study for M.I.T. is that the social problems of our time require all the insights a diverse academic community and broadly educated individuals can offer. □

ILLUSTRATION: PAUL MOCK

Going Public: The Ultimate Test of a Company's Strength

Pounding the pavement between venture capitalists, corporate planners, bankers, and private investors may be the way it all begins, but the first big-time test for a new enterprise is "going public"—printing stock and letting Wall Street set the price.

That's when you have to "articulate your objectives, sharpen your strategy," says George N. Hatsopoulos, '49, founding president and chairman of Thermo Electron Corp., Waltham, Mass. "It's like teaching a class of bright students. If there's a hole in your argument, the investors will find it."

Hatsopoulos was speaking late last fall at the annual workshop of the M.I.T. Enterprise Forum of Cambridge, the flagship group in an expanding alumni-based national movement to share the wisdom of experienced entrepreneurs. There are now Enterprise Forum affiliates in 12 cities in the U.S. and Mexico, conducting monthly case clinics on start-up companies, annual workshops, and a variety of other programs—a total involvement perhaps 4,000 successful and would-be entrepreneurs every year.

Two pioneers of this movement were honored at the Cambridge workshop with the first Enterprise Forum Outstanding Service Awards:

☐ Jerome Schaufeld, consultant-adviser to entrepreneurs and entrepreneurial activities, for "inspired foresight and leadership" as the first chairman of the Enterprise Forum of Cambridge.

☐ Vincent A. Fulmer, S.M.'53, former secretary of M.I.T., for his "distinguished career in the high-technology community as counselor to companies and universities." His only weakness, said Fulmer's citation: he is "unable to say no when asked to help."

In a plenary session of an all-day workshop devoted to "Financial Options in Uncertain Times," Hatsopoulos described why he chose to offer stock in Thermo Electron Corp. to the public in 1966. Simply, the company had more good, new ideas than money to spend on them. After 10 years Thermo Electron was an undoubted success, but it had sales of only $2 million a year on a limited range of highly specialized products. Now it was ready to diversify with power sources for prosthetic devices and space experiments, as well as systems for measuring trace quantities of metals and other substances.





Cambridge Workshop Chairman Arthur Parthé (top, right) presented the first Enterprise Forum Outstanding Service Awards to Jerome Schaufeld (top, left) and Vincent Fulmer, S.M. '53 (bottom).

The strategy worked: 18 years later Thermo Electron is a $300-million-a-year company, and Hatsopoulos speaks the language of Wall Street as easily as that of magnetohydrodynamics.

Raymond S. Stata, '57, first put stock in Analog Devices, Inc., on the market in order to reduce the company's debt. Analog Devices had been started with capital borrowed from banks. The company retained its earnings and borrowed more against them, and finally the burden of bank debt was too much.

A very different strategy motivated Analog Devices' second stock offering two years ago. Then the company was about to embark on a new venture—the manufacture of semiconductor chips, risky in the face of "formidable competition," said Stata. The financial markets at that time were volatile—also risky. That added up too much uncertainty, said Stata, and so he turned to the equity market. "The optimum strategy," says Stata, "is to balance business and financial risks."

But then Stata surprised his audience: most U.S. industry is "underleveraged," he said—the low ratios of debt to equity are too low. "Part of your job as an entrepreneur is to take prudent risks, and if you are taking too little risk that is not good management."

When ASK Computer Systems, Inc., Los Altos, Calif., mounted its first public offering, the goal was not money but visibility and customer confidence in its struggle against IBM and Hewlett-Packard. Founder Sandra Kurtzig, who's recently retired from the full-time presidency to be chairman of the company, remembers the experience as a good one. Despite the high cost of all the lawyers, accountants, and printers and the problem of learning a whole new jargon-filled language, there was the positive result of "having to stand up to the questions of the investment community. That's when we did our best business plans," she said.

Indeed, they may have been ASK's first business plans, for Kurtzig's company is the stuff of which entrepreneurs' dreams are made. ASK Computer Systems started out writing computer programs 10 years ago in Kurtzig's spare bedroom, without a business plan and with almost no money. As the business outgrew the bedroom, Kurtzig "opened a 'branch office' in the living room."

When ASK needed a computer to test its software, Kurtzig tried talking to venture capitalists about her software ideas, but "they thought they were hearing about women's underwear." So she borrowed the money she needed from her father. Later Hewlett-Packard let ASK use some of its computers during underutilized night-time hours, so ASK added some sleeping bags to the company's assets. From these beginnings ASK has grown to a $100-million-a-year software sales and service business.

Competing for Money

Not everyone takes Kurtzig's dim view of venture capitalists. Kenneth H. Olsen, '50, says his Digital Equipment Co. would never have been started without American Research and Development, the only source of risk capital he could find in recession-burdened 1957. General Georges F. Doriot of AR&D gave Olsen three pieces of advice along with a $70,000 investment: 1. Don't use the word "computer," because *Fortune* magazine had just said no one was going to make money in computers; 2. Don't promise 5 percent profit because that's not enough ("so we changed it to 10 percent," recalled Olsen); and 3. Promise quick results because "most of our investors are over 80."

Today venture capital is bigger and more sophisticated than when DEC began. But not so big as several years ago, when capital gains taxes were lowered and new money flooded the market. That frenzy of activity has subsided to "more normal" times, said Linda S. Linsalata, vice-president of Investments Orange Nassau, Boston. Lots of money is still around, but there's more competition for it, she said. And some investors are not seeking opportunities as aggressively as they did, Linsalata said. Today's venture capitalists are busy protecting the value of their portfolios by helping to manage companies in which they invested two years ago. "We make money helping our companies be good companies," she stressed.—*John Mattill* □

An Engineer's Comeupance: Entrepreneurship Is Also a Manager's Game

BY PETER MUI, '83

When we were undergraduates in engineering, we generally thought of management as being for those who could not cope with the analytical discipline of our engineering curricula. As we saw it, training in organization and management were superfluous to our roles as producers and innovators. Reducing the number of circuits or gears in our designs was done to optimize performance, not reduce cost. Constraints such as time and money were really secondary in solving the technological problem at hand. Do it right, said our engineering credo, and the world will always beat a path to our door and the better mousetrap therein.

But the world is not quite as we saw it. We may know how to do and to recognize innovation, but our engineering experience turns out to have left us somewhat naive as to the economic realities of product development. The extensive resources and management hierarchy we called "overhead" in large companies were in fact assets, and their absence was a major bottleneck in our fledgling enterprises. Management's relationship to engineering wasn't parasitic but symbiotic, and our lack of skills in the board room threatened our project's viability as much as difficult problems in the laboratory.

So some of us swallowed our pride last fall and signed up for the Enterprise Forum's workshop on "Financial Options in Uncertain Times," acknowledging the possible role of management skills in bringing the fodder of our brains to tangible and economic reality.

As it turned out, the day belonged to those management types, and they gave it to us good. Our qualifications and motivation were questioned at every turn: "Learn that being an entrepreneur means living 'low off the hog'!" chided one panelist. Were our marketing and communications skills adequate? Could we motivate individuals into a team? Did we need to "feed people to our egos?" At lunch, Kenneth Olsen of DEC emphasized the need for "a downtown bank, downtown lawyer, and downtown accounting firm" as the initial acquisitions for an emerging company. "Chutzpah" was the key concept at an afternoon workshop on stretching company finances. "Delay paying everyone as long as you can, except for your accountant," advised the CPA on that workshop panel.

The jargon was as thick and furious as a thermodynamics class. Undercapitalization. Retained earnings. Two percent ten net thirty. One budding entrepreneur's admission that he didn't know what was meant by a "big-eight accounting firm" brought hearty laughter from the career financiers, nervous laughter from the rest of us.

For those of us considering starting, or already involved in, our own small companies, the day was sobering but not demoralizing. We engineers learned that there are some clever ways to get more out of our financial resources and that we must have financially astute people close to the top of our companies' management. Furthermore, at each break in the scheduled agenda, the handshakes and business cards flew, as the haves and have-nots on boths side of the high-tech start-up equation rushed together and scattered again like sub-atomic particles in a cyclotron.

Would our business ventures succeed? Clearly not without proper financial leverage and astute management. And the message of "no free lunch" at the workshop was clear. Still, it takes a certain personality type to even consider being an entrepreneur: that same stubborn resoluteness that kept us up late to finish a problem set or to get that last bug out of a program now makes us willing to take a chance on ourselves. □

PHOTOS: DONNA PAUL

Olsen on Entrepreneurship: Melding Innovation with Responsibility

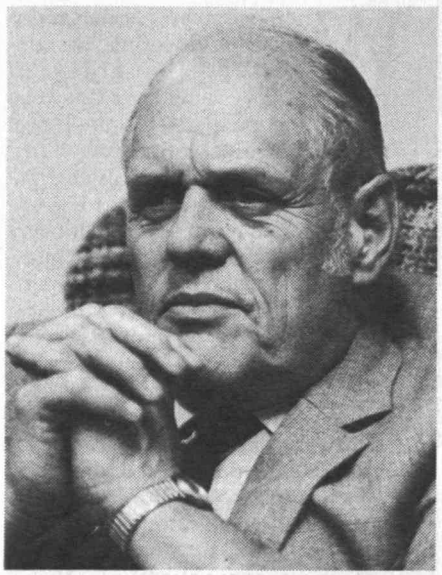
Following is a condensation of the remarks by Kenneth H. Olsen, '50, president and founder of Digital Equipment Corp., at the Enterprise Forum workshop in Cambridge on November 16. An account of the workshop appears on pages A4 and A5.

When we started Digital Equipment Corp. 28 years ago we had some wild ideas.

Our first idea was that we would not take government money. It had been our observation that government funding corrupted any company that wanted to be a commercial success. We also said we wanted to make a profit—a wild idea when profit was still a bad word for many people. We also said that growth was not a goal, that our idea of being successful was being a company that would be long-lasting and that we'd be proud of. Not to put growth first, but to let it come naturally, has been a policy of the company ever since.

In 1957 there was just one company in the risk capital business, American Research and Development, and they gave us $70,000. The nice thing about $70,000 is you can watch every one of them. We went to Maynard, Mass., and rented one floor of an old woolen mill—9,000 square feet of space. We put up some partitions, bought lawn furniture to sit on, and cleaned the johns and swept the floor ourselves. But we took some good advice from American Research and Development: "Get a downtown bank, a downtown lawyer, and a downtown accounting firm," they said, and for quite a while our accounting cost us more than our manufacturing.

In the beginning, doing all the planning, engineering and manufacturing was a very important experience. We made our own printed circuit boards. We did the photography in my basement, silkscreened the boards with real silk on wooden frames, etched them in an aquarium tank, and soldered them by hand. We were making transformers with little ferrite cores, and we found the edges of the cores were sharp and would wear the insulation off the wire so the transfomer would short-circuit.



It was M.I.T.'s openness and honesty that DEC tried to emulate.

So we bought a kitchen canister from the five-and-ten, put some sand in it, and attached it to the wheel of the bandsaw that rotated slowly. If we left the bandsaw on overnight with the cores inside the canister, they would be well rounded by morning.

With this approach, we developed a good feeling for business, and we grew quite well. But while we grew we also wanted to retain the spirit that we knew generated the company's creativity and drive—the openness, honesty, trustfulness, and generosity we'd all felt at M.I.T. Indeed, it was that spirit much more than anything technological that inspired us to start a business. So we ran the company as a committee of about 20 people, and we made decisions as a group. That just felt right to us.

But we found that running a company by committee didn't work. Each of the 20 people had ideas of how to spend money, and I was the only one with the responsibility of making sure we didn't spend more than we took in. So 19 people grew terribly unhappy with me.

I finally got everybody together and said, "Now we're a new company. Nobody tells anybody else what to do. Each of you has responsibility for everything in your part of the company. In other words, you, you, you, and you are entrepreneurs, and everybody else is a service." It went over like a lead balloon, because everybody felt demoted. Before that all 20 were vice-presidents over everything, but suddenly each seemed to have only a little responsibility.

But then a miracle happened. After each of those people learned what were his responsibilies and his resources and how he was going to be measured, we began to work well again. Each made plans and measured himself against them, the same way that I was measured. They were in control, and they did well.

Our goal was to introduce computers as we knew them at M.I.T. to the many markets where they were needed—often to people who didn't know they needed computers at all. Our approach to computers at M.I.T. had been different from that of the rest of the world. We had made very simple, very fast computers, and we made them so well that they could be used by anyone.

At that time most computers were behind at least two layers of glass and kept away from anybody who wanted to use them. The best example was right here in Building 24, where a computer given by IBM was housed in a special wing. People would bring their problem in the form of a stack of IBM cards to the front of the room, where the next day they could pick up the answer. It would usually say, "You made a mistake."

On the floor above, meanwhile, the TX-0 computer we had made at Lincoln Laboratory was wide open. People could sign up for it 24 hours a day, months ahead, do anything they wanted; no one supervised. It became

Power doesn't come from telling people what to do; it comes from learning what goes on.

so popular that students stopped going to class, stopped going out with girls, even stopped eating to use it. It was that kind of computing that we wanted to introduce to the world. We ended up with a machine that was thoroughly engineered in every detail but basically remained very simple to use.

To sell these computers we broke down the market for them into a number of segments. And we had marketing units that sold computers to each particular segment—newspapers, laboratories, machine shops, and the like. At first the results were very good. We were growing very fast, selling a lot of computers, making good profit.

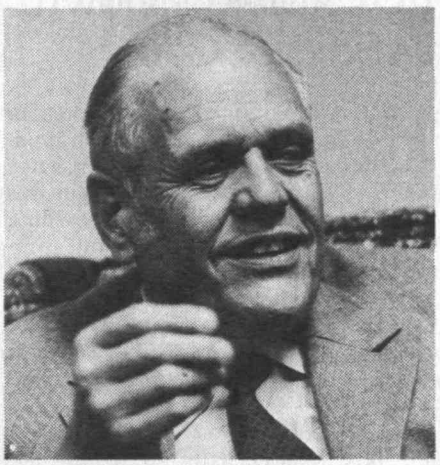
Success is probably the worst problem for an entrepreneur. Someone who is successful finds it all too easy to believe he can do anything. He confuses responsibility with authority. He forgets that power doesn't come from telling people what to do; it comes from learning what goes on.

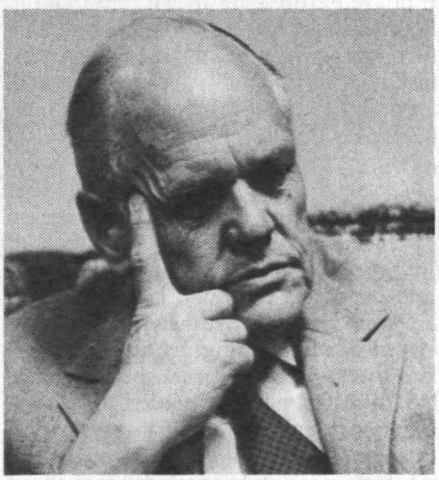
And as people get to be successful, they tend to stop learning. If you're too successful, you can delegate the learning to someone else, and then suddenly you find you can't run the business. I asked a vice-president, "What happens if you raise the price 10 percent?" He answered, "I don't know. . . . I'll ask my financial analyst." But a good vice-president should be able to do the calculations himself—at least to within plus or minus 10 to 20 percent.

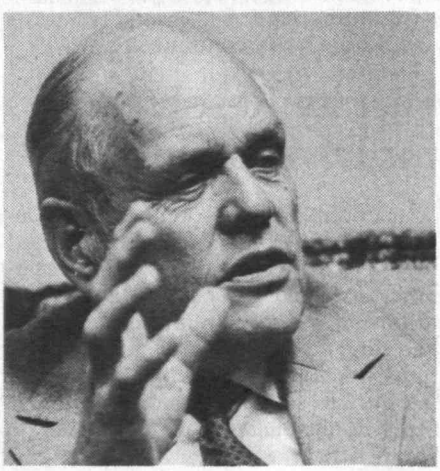
A New Strategy of Specialization

We started by making very different things quicker and better than anybody else and selling them to people who needed them most. But ten years ago it became clear that we couldn't hold on to all the markets in which our share was 100, 90, 80, or even 70 percent. Those markets were just growing too fast. We had to do something harder—evolve a different business strategy. So we took as our challenge integrating, networking, and communicating among all our computers.

So all through the 1970s we worked







on one protocol for networking all our equipment; we call it DECnet, and it's probably the most commonly used protocol today. We also decided that we had to have one computer architecture and one software system for everything. So for ten years, 1,000 people or more worked on a hill in New Hampshire on that single software system and all its languages.

Thus after a tradition of many independent groups each pursuing a different product, we became a single integrated company putting all of the corporate resources in one or two directions. I even boasted publicly that we were one company with one strategy.

When our entrepreneurial people heard that, a lot of them were upset and some of them quit. They didn't want to give up their independence; every entrepreneur wanted to do his thing. But in the end the result, as you might guess, has been beautiful. Everyone is working together.

What is the position of entrepreneurship in this new strategy? It is stronger than ever. For example, we set our people up in France, Germany, and England as entrepreneurial groups. When our group in England wanted to build a manufacturing facility, we said yes, and they built exactly what they had proposed. Shortly afterwards they came back to complain, "Other companies built more and are doing better. You didn't give us enough." My answer was, "You didn't ask for enough." It took a long time for them to realize that when it was finally approved, their plan was their responsibility. But when they finally realized that, their pride was stimulated and they made it work, right or wrong. That's the secret of entrepreneurship: even if you don't plan it right, if you're in control, you make it work anyway.

We run a complicated business—$7 billion a year, all integrated, not broken down in divisions—in which everything is interdependent on everything else. The only way I know to run it is to make the one who proposes something responsible for it. □

PHOTOS: KAREN MCCARTHY

SMALL BUSINESS CAREER OPPORTUNITIES CONFERENCE

Saturday, April 5, 1986

Alumni and students are invited to attend the Small Business Career Opportunities Conference to learn about the career paths and opportunities available in smaller companies. Over 50 companies in all facets of technology and business will be represented.

In the morning seminar, five speakers will discuss the interviewing and hiring process and the working environment in a small company and how it differs from that of a larger firm.

An afternoon career fair will give alumni and students the opportunity to meet informally with company representatives to learn about specific job opportunities.

• 9:30 a.m.–10:00 a.m.
Registration: Coffee & Donuts
Room 9-150

• 10:00 a.m.–12:00 p.m.
Seminar: "Small Business: Interviewing, Recruiting, and the Working Environment"
Room 9-150

• 1:00 p.m.–5:00 p.m.
Career Fair–Opportunity to meet informally with company representatives
Kresge Auditorium

The conference is open to all alumni and students, free of charge. However, space is limited for the seminar. Please fill out and return the form below to ensure a space. Unreserved seats for the seminar will be on a first-come, first-served basis.

For more information contact:
Marianne Ciarlo (617) 253-4735
Susan Kline (617) 253-6140

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SMALL BUSINESS CAREER OPPORTUNITIES CONFERENCE
Saturday, April 5, 1986

I will attend the ☐ Seminar ☐ Fair

Name Class

Address

Phone

Please return form to:
Louise Carella
M.I.T., Room 1-207
77 Massachusetts Avenue
Cambridge, MA 02139

EECS Majors Down as Science Gains

Efforts to interest sophomores in majors other than electrical engineering and computer science (Course VI) have succeeded again this year. The net effect is that overcrowding in EECS is being reduced without jeopardizing the traditional freedom of M.I.T. students to major in the program of their choice.

As of late October, 316 sophomores had signed up to major in EECS, compared with 350 a year earlier. No other changes in sophomore preferences last fall were so large, with the result that, though enrollment in all other engineering departments increased, the total of engineering majors was lower than last year. Mechanical engineering and aeronautics and astronautics made substantial gains.

The most spectacular growth, however, was in the School of Science, whose sophomore registrations were up nearly 25 percent over 1984. Much of that increase was students majoring in two programs designed last year to relieve EECS overcrowding—physics with electrical engineering (22 sophomores) and mathematics with computer science (18). Physics nearly doubled its sophomore enrollment, from 56 last year to 96 this year. And biology enrollment was up, too—enough to spark concern about a future shortage of space and resources should the trend continue. ☐

Faculty Resolves for Divestment

In a nonbinding resolution late in December, members of the faculty voted 131 to 40 to urge the M.I.T. Corporation to "take every possible step . . . to hasten the dismantling of apartheid and the achievement of full political rights for all South Africans . . . including the divestment of holdings in those firms doing business in or lending to South Africa."

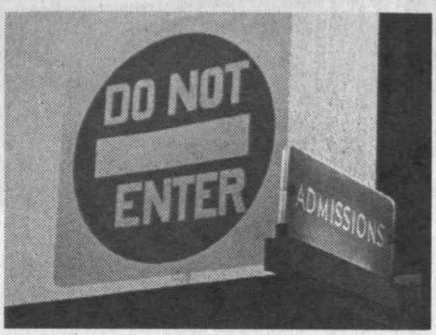
President Paul E. Gray, '54, who presided at the meeting, said he would inform the Executive Committee of the Corporation, which has the responsibility for investment policy and was already discussing M.I.T.'s position on holdings linked to South Africa. Gray emphasized that the vote "is advisory to the Corporation and does not in itself constitute any change in M.I.T.'s investment policy."

In a letter to the faculty prior to the meeting, President Gray discussed his view that divestment is not an effective strategy to end apartheid and not an appropriate action for the university to take. Not only could divestment decrease M.I.T.'s endowment income and strain its relations with industry, he said, but a university that uses its economic strength to influence political issues with no direct bearing on its educational and research programs runs the risk of exposing its academic activities to "political treatment."

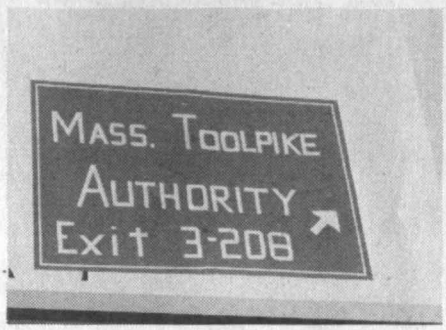
M.I.T.'s general investments, including endowment and other invested funds, currently amount to about $930 million. About 18 percent of that—about $160 million—is invested in U.S. corporations with operations in South Africa, according to Glenn P. Strehle, '58, treasurer.

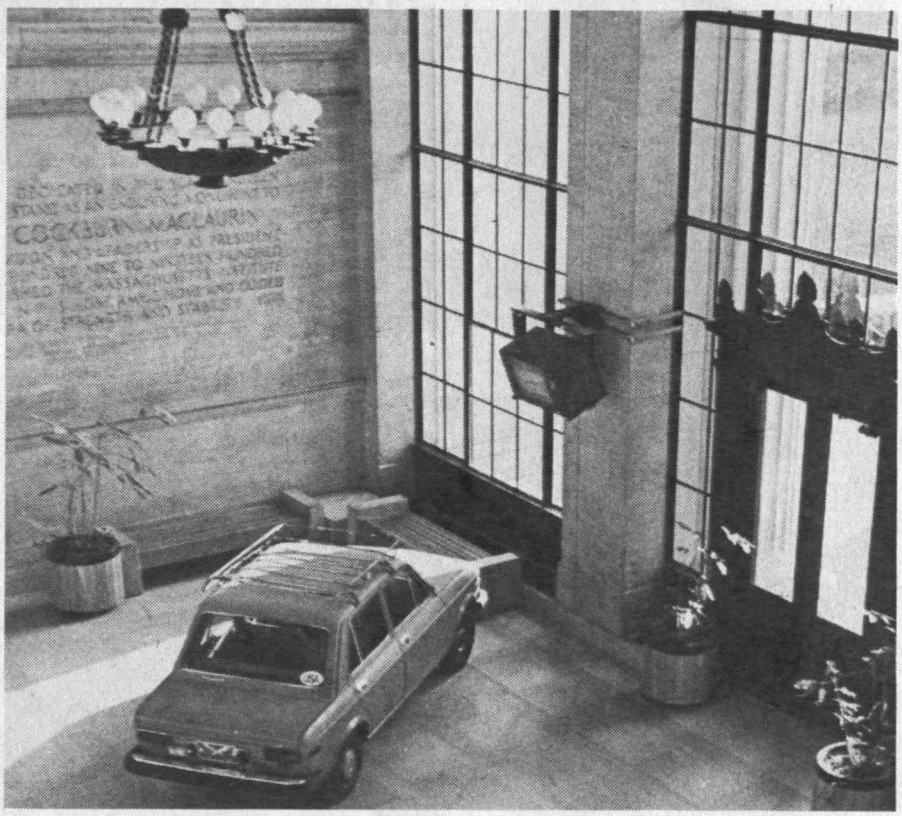
Strehle believes that income on these invested funds would fall if the faculty's recommendation were adopted. "South-Africa-free portfolios prepared by banks showed losses of 1.75 to 9.9 percent over five years," Strehle said. And President Gray argued that corporations dropped from a university's investment portfolio would likely also discontinue their support of the university. There is inconsistency, he argued, in divesting and yet seeking and accepting continued support from the same source.

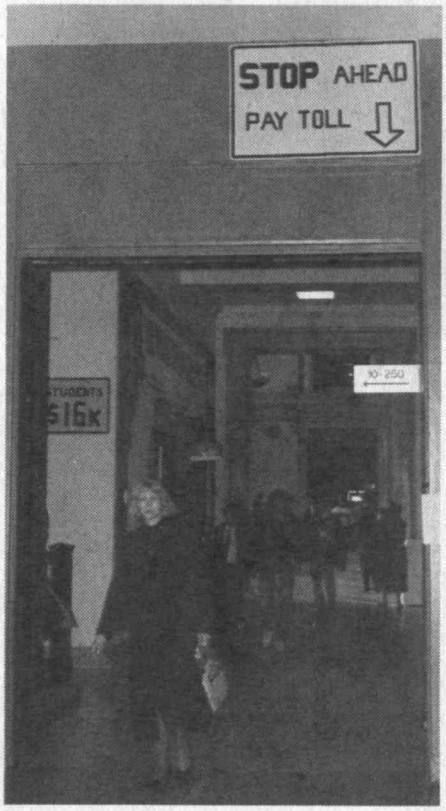
Professor Willard Johnson of the Department of Political Science, who brought the issue to the faculty, urged divestment as "the only thing that we can do that might really shorten the transition (away from Apartheid) and save lives." Already more than $4.3 billion has been denied the financial mar-











In one of the most ingenious hacks of recent years, the "infinite corridor" was transformed overnight into a "toolpike" late last fall. A Fiat was neatly parked in Lobby 10, a traffic circle installed in Building 4, and appropriate signs posted in well-chosen neighborhoods. "Commuters" heading for Mass Ave. were directed to "Exit 77—The Real World," and there was much admiring speculation about how the Fiat was brought in.

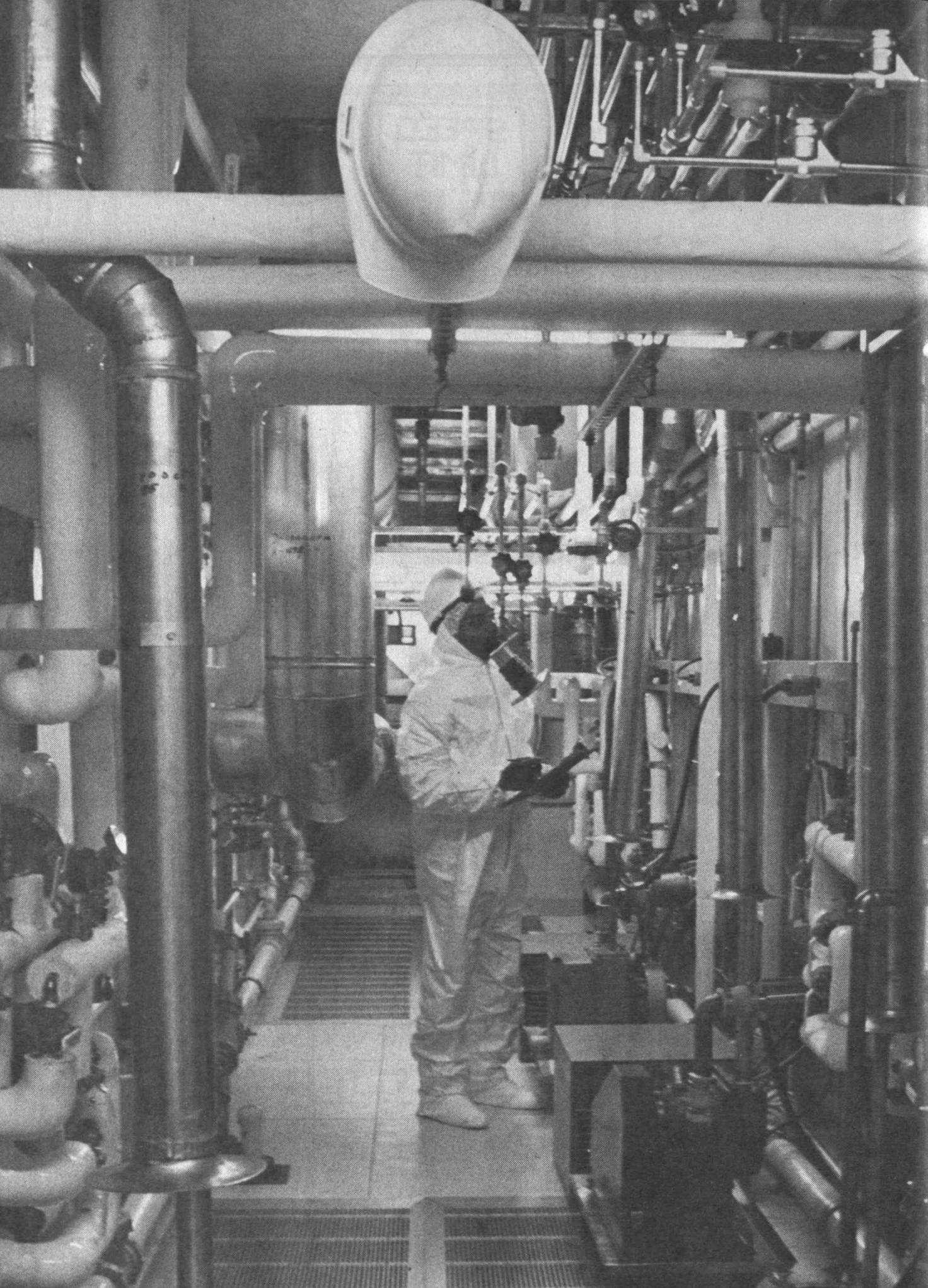
kets of companies with South African operations, he said—a campaign that destroyed the U.S. market for Krugerrands, even before Reagan's ban on their continued importation. Indeed, said Johnson, so many investors are now concerned about keeping free of South African ties that brokerage houses and financial managers are competing to show themselves capable of managing South-Africa-free portfolios.

Professor Gretchen M. Kalonji, '80, who seconded Johnson's motion, spoke on the role U.S. corporations play in South Africa. For example, the South African government is IBM's single biggest customer, she said, explaining that IBM mainframes are used to store the database of passbook information about people who are considered non-white. She emphasized the strategic nature of this involvement: "Incapacitation of a single computer would necessitate finding hundreds of bookkeepers, who may not be available at short notice on the labor market."

Professor Franco Modigliani spoke against the motion, though he noted that his own experience of oppression in pre-war Italy makes him particularly sensitive to the situation of blacks in South Africa. His concern was whether the trustees of funds given for institutional support have the right to exercise political or even ethical judgments in managing those funds.

President Gray responded by reporting that outside counsel had been asked by M.I.T. to study the question. In a "near-final" draft report, said Gray, counsel noted that, although there is considerable ambiguity, "in the case of the Institute's pension funds, the duties of care and loyalty do not permit the selection of less economically attractive investments simply to avoid investments that are related to South Africa. In the case of the endowment funds, the same principles apply, but there is some scope to consider other factors that relate to the purposes and needs of the Institute, at least with respect to the portion of the endowment that is unrestricted." □

PHOTOS: ADAM KANE, TECHNIQUE; CALVIN CAMPBELL



A World-Class Center to Pursue Ultraminiature Technology

Electrical engineering's new world of microcircuits and submicron devices came into its own at M.I.T. on December 6 with the dedication of a renovated building housing $23 million worth of Microsystems Technology Laboratories (MTL) and a Submicron Structures Laboratory (SSL). The building, in its new role, was named in honor of Gordon Stanley Brown, '31, former head of the department and dean of the School of Engineering.

Professor Richard B. Adler, '43, associate head of the Department of Electrical Engineering and Computer Science, describes the new MTL, under the direction of Professor Dimitri A. Antoniadis, as "second to none among universities worldwide."

The goal of the new facilities is to give M.I.T. faculty and students full partnership in the technological revolution achieved by microcircuits. "No university that strives for excellence in electrical engineering and computer science can neglect this fast-moving field," says Professor Paul L. Penfield, Jr., Sc.D.'60. Penfield is the director of the Microsystems Research Center (MRC) that coordinates M.I.T.-wide research activities in microelectronics.

The basic unit of exploitation is the same as it was when Brown learned electrical engineering 50 years ago—the electron. But the torrents of electrons that flowed through the first electrical machines have now been reduced to trickles and even droplets. Conductors measured in centimeters and devices measured in feet have given way to lines and chips measured in microns.

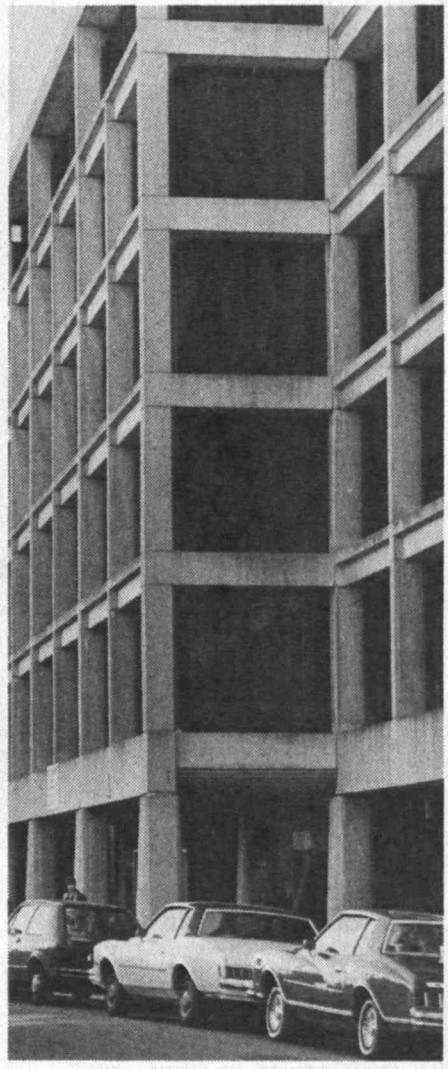
Indeed, miniaturization is the key concept—making electronic components as small as possible and linking them with ever-finer conductors so they can be packed into the smallest possible space. The goal is speed—faster operation of individual devices because they are small, and faster operation of circuits because the components are closer together. This is the route, for example, to ever-more-powerful computers, able to perform more operations in less time and space.



Harder to build, more expensive to outfit, microcircuit technology labs are sine qua non for EECS of the future.

"Submicron" is an adjective that applies to nearly everything those using the new facilities do and want to do. For example, making conductors as small as 1000 angstroms in diameter (0.1 microns, or 0.00001 centimeter) will be routine in the SSL. (SSL, though one of three major laboratories housed in the Brown Building, is administratively a component of the Research Laboratory of Electronics.) Even before the new facilities were completed, Stephen Chou,

Continued on page A12



Building 39 (above) has been transformed into a research center on microcircuits and submicron devices—the revolutionary new mainstream of electrical engineering—and named for Gordon S. Brown, '31 (above, right). As chairman of the department and then dean of engineering, Brown presided over an earlier revolution in engineering education. His delight was apparent as David S. Saxon, '41, chairman of the Corporation paid him tribute at the dedication.

PHOTOS: CALVIN CAMPBELL, KEVIN GALVIN

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Scenes such as this are the wave of the future: a silicon wafer is examined in a clean room of the Gordon S. Brown Building in preparation for final processing into a microcircuit component.



Continued from page A11

a physics graduate student from Beijing, had used SSL's x-ray lithography system to create the world's smallest transistor. It's a step on the way to what Professor Henry I. Smith, SSL's director, calls a new family of extremely small "quantum-effect" devices.

There are also facilities for research on microcircuits—large assemblies of tiny devices can be designed, made, tested, and packaged in the Integrated Circuits Laboratory. In addition, to support these activities, the Brown Building houses a Technology Research Laboratory and a network of VAX 750 and VAX 785 computers with access to other campus computer facilities.

All areas of design, fabrication and evaluation of integrated circuits, devices and microstructures are represented in the Brown Building. Large state-of-the-art integrated circuits and systems can be processed from concept and starting materials through final test and packaging. Individual process steps can be isolated and studied in acute detail. Advanced devices can be developed and comletely characterized. Ultrasmall patterns can be created for diverse purposes (including some that may not necessarily be related to electronic devices).

Our Most Energy-Intensive Building

To create the new laboratories in Building 39, M.I.T. first moved the previous occupants, the Information Processing Center and the Industrial Liaison Office, to other locations. Then Building 39 was completely gutted and rebuilt—the latter being a particularly critical job because of the special requirements of microsystems work.

Vibration and dirt are intolerable. Failure can be caused by a single speck of dirt the size of a circuit element or a vibration that imperceptably shakes an x-ray submicron lithographic machine. There are also critical requirements for humidity and temperature.

Accordingly, the Brown Building contains 3,800 square feet of what is called Class 10 laboratory space—fewer than 10 dust particles 0.2 microns or larger per cubic foot of air. Another 5,500-square-feet of Class 100 laboratories have fewer than 100 dust particles of 0.5 microns or larger per cubic foot.

All these areas are isolated from vibration. A tough job, says David Peters of Symmes, Maini and McKee, architect/engineer for the renovation. Not only were all the fans, blowers, and filters to control the clean rooms located inside the building; there was also one of the Institute's entrances directly beneath it, trucks on nearby Vassar Street, and a wind tunnel and power plant adjacent.

The extensive ventilation and filtering equipment and the machines used to etch and process microelectronic devices consume electricity at enormous rates. As a result, the Brown Building is the most energy-intensive building at M.I.T. It's also among the most expensive, since microelectronics facilities generally cost at least five times as much as conventional laboratory and manufacturing space, according to Peters.

Some 60 graduate students and 40 faculty members will be involved in the Microsystems Research Center, says Penfield. The renovation project was funded by a combination of industrial grants and government support; almost all of the donor firms, which constitute the Microsystems Industrial Group, are providing about $1 million annually of continuing support for general operations. In addition, MRC research will be about $8 million annually, says Penfield, including two industrially-sponsored efforts to develop novel chips: one a large, content-addressable digital computer memory and the other an extremely fast, highly accurate analog/digital convertor.

Though microelectronics research will continue in many parts of the campus, the Brown Building gives M.I.T. a special edge in the fast-moving new field, says Adler. "The combination of submicron structures technology and integrated circuit processing in the same building is very powerful," Adler says. "We can undertake research that can only be dreamed about elsewhere."—*John Mattill* □

A Reputation for Energy and Brilliance

Back when he was head of the Electrical Engineering Department, they called him "bulldozer Brown." But Gordon S. Brown, '31, thinks the honorific is an exaggeration. After all, he says, he *did* warn then-President James R. Killian, Jr., '26, before he disposed of the entire contents of the large electrical machinery laboratory in the basement of Building 10.

Brown's friends and colleagues, assembled for a nostalgic dinner to mark the dedication of the new Gordon S. Brown Building, question his version of the story. As they remember the head of the department, such diplomacy was at best atypical—and most unlikely. But Brown insists that Killian's only question was, "How fast do you want to do it?"—evidence that Brown's reputation was even then secure.



(Left to right) Gordon S. Brown, '31, works with his wife Jean, Paul E. Gray, '54, and Gerald L. Wilson, '61, to unveil a dedication plaque.

The Aussie Impressed Vannevar Bush

Indeed, almost from the day he arrived at M.I.T. from Australia as an undergraduate, Brown acquired a reputation for moving quickly, with vigor. "We loved his energy and brilliance," recalls Katherine Hazen, whose late husband Harold L. Hazen, '24, had just joined the faculty when Brown arrived. Vannevar Bush, '16, then a senior professor in the department, apparently shared that judgment, giving Brown a summer job helping set up a new vacuum tube laboratory. Three years later, as a graduate student, Brown was made head of the department's Research Division, where he did a doctoral thesis under Hazen on servomechanisms.

President Paul E. Gray, '54, credits Brown with "changes of epochal significance" in the M.I.T. electrical engineering curriculum soon after becoming department head. Gray knows from personal experience: he was an undergraduate then. Discarding the electrical machinery laboratory was a small part of it. There was new emphasis on the scientific basis of electricity, electronics, and communication. "All the electrical engineer has to work with are charge carriers," wrote Brown, ". . . either ions, electrons, or holes, their associated electric and magnetic fields, and their interaction with materials. Out of this basic nucleus of carriers, fields, and material, the engineer builds configurations of devices, machines or systems that do either of two things—they process energy or they process information. That's all."

Brown brought the same emphasis and the same zest for reform to the entire engineering curriculum when he became dean in 1959. Gerald L. Wilson, '61, today's dean of engineering, recalls that influence in one sentence which he attributes to Brown as dean: "First-rate engineers are scientists who have completed their education."

Perhaps the most colorful recollection of many during the ceremonies for the new Gordon S. Brown Building is credited to President Gray. He told of a last-minute change in plans that kept Professor David C. White from visiting the Birla Institute of Technology and Science in Rajasthan, India, in the early 1960s. Brown, who had established the Birla-M.I.T. link, recruited Dr. Gray, then a faculty member in the department, and Robert P. Greene, '55, then an administrator in the Dean of Engineering's Office, to go instead. Accordingly, the visitors arrived to find Birla's president puzzling over Gordon Brown's telegram, which read: "White can't come. Gray and Greene will arrive soon. Signed Brown."—*John Mattill* □



PHOTO: M.I.T. MUSEUM

BY DIANA BEN-AARON, '85

Florence Luscomb, 1887-1985
A Century of Commitment

In Florence Luscomb's senior year at M.I.T., 1908-1909, *The Tech* reported that the "Tech Co-eds" had formed a secret "Woman's Suffrage Club" and kept the names of its officers "in the dark."

There are no other records, but Luscomb was almost surely among the anonymous leaders. Even as an undergraduate architecture student, she was a well-known advocate of the vote for women. But it must have troubled her to participate in an organization that conducted its business in anything less than the full light of a public podium.

Her style throughout a life of political activism on behalf of women, blacks, labor, and world peace was not only to make speeches and march in demonstrations, but to publish her own remarks for anyone who might have missed them the first time around.

When she died on October 27, 1985, at age 98, Luscomb was believed to be M.I.T.'s oldest alumna. But her career was no artifact of ancient history: in 1952 she ran for governor of Massachusetts under the Progressive Party platform of "Feminism, Socialism, and the Peace Movement," and in 1975 she was still getting newspaper coverage of her calls for legislative reform.

Luscomb went to high school at the Chauncy Hall School in Waltham, Mass., which functioned at the time as a preparatory school for M.I.T. "When I was there, most of my boy fellow students were going on to M.I.T. And I thought to myself, 'Well, why shouldn't I go to M.I.T.?' " she said. "Mother [Hannah Knox Luscomb, also a noted activist] wasn't especially anxious for me to go to college or go to M.I.T., but if that's what I wanted to do, she would finance it."

Little of Luscomb's life at the Institute can be divined from the records of *Technique* or from *The Tech*. There were twelve women students when she entered, and no housing for women. Luscomb lived in Allston with her mother and walked six miles a day to and from M.I.T. She served as treasurer and vice-president of Cleofan, the Institute's local sorority, whose membership appeared to encompass all women students. In her last year, *The Tech* reported that the "Woman's Suffrage Club" had posted "gorgeous yellow placards declaiming the present state of tyrannical opposition to women voters and calling for a new system of apportionment of national representation."

She went to 11 architects before she found one who would take her in.

In the South End, Luscomb's name was a household word.

"The Tech men gathered in laughing groups around the posters, speculating on their authorship. The suffragist organization is secret, and although the *Tech* boys have tried to find out who its officers were, the names have been kept in the dark," the article concluded.

The presence of such organizations, and of Ellen Swallow Richards, who served as unofficial dean of women, must have provided needed solidarity at a time when women were so far out of the mainstream at M.I.T. that men played women's parts in the annual Tech Show. It was not, by and large, an era of social enlightenment at the Institute: M.I.T. offered Esperanto on Tuesdays and Thursdays in the hope of increasing world understanding, yet a *Tech* review of a black singing group ran under the headline "Darkies' Music Praised."

Even as a student looking for a summer job, Luscomb encountered discrimination against women in architecture. "I went to 11 [architects] before I found one that would take me in, even for no wages at all," she said. After graduation, she worked for and later went into partnership with another woman, Ida Annah Ryan, '05, the first woman to receive the Master of Science in Architecture. Ryan's design for a soldiers' home had won her the Rotch Traveling Fellowship in Architecture in 1906, again a first for women.

Ryan was equally committed to women's suffrage, and allowed Luscomb to use working hours to participate in suffrage activities. When the United States entered World War I in 1917, all building stopped, allowing Luscomb to devote herself to the cause full-time. When the war ended, she took a paid job with the Boston Equal Suffrage Association and never worked as an architect again.

"Florence Was the Only White Person He Fully Trusted."

After seeing the nineteenth amendment passed, Luscomb applied her organizational skills to the labor movement and to civil rights. A charter member of the NAACP, she served on its board for many years. "Discrimination against women is bitter," she said, "but it is to me nowhere near as oppressive as discrimination against black people. Each discrimination, though, helps the other. It's all one battle."

"When my sisters and I grew up on Northhampton Street in the South End ghetto, the name Florence Luscomb was a household word," said William Worthy, an associate of Luscomb's who spoke at a well-attended memorial service last December. "My mother knew her in the Women's International League for Peace and Freedom. Both parents knew her in the NAACP. Our family dentist down the street, Dr. Robert A. Simmons, said Florence was the only white person whom he fully trusted."

She also served as vice-chairman of

"Probably in every crusader there is an inner voice crying out for acceptance by society at large. Florence never listened to that voice."

the Massachusetts chapter of the American Civil Liberties Union (ACLU), and much of her energy during the 1950s went toward defending civil liberties. In 1956, she won a suit in the state Supreme Court against the Massachusetts Commission for Investigating Communism and Subversive Activities. Her remarks to the commission, privately printed by her as a leaflet, read in part, "I stated in the beginning that I knew of no one among my personal acquaintances who was subversive. I do know of subversion abroad in our land. . . . It is subversive for commissions like this to spread such intimidation and hysteria throughout the land that Americans are afraid to sign petitions, afraid to read progressive magazines, afraid to make out checks for liberal causes, afraid to join organizations, afraid to speak their minds on public issues."

"Florence once said the best way to enjoy freedom of the press is to own one. And she owned one," said Judge Lawrence Shubow, another speaker at the memorial. "It was a Mimeograph machine and it was as powerful in its own way as the presses that churn by day and by night on Morrissey Boulevard and other such places. And I as a youngster growing up in Dorchester got more of my education from the products of the printing presses of the Florence Luscombs than I did in the sanctified halls of Harvard College."

The Threat of Respectability

In 1980, the University of Massachusetts awarded Luscomb an honorary degree. "The media and Boston establishment began very late in her life to recognize her ability and accomplishments," Worthy noted. "They came to honor her and admit her to respectable society. The threat of new-found respectability did not deter her. Probably in every crusader there is an inner voice crying out for acceptance by the society at large. Florence never listened to that inner voice."

Barbara Brown, a member of the last household Luscomb lived in, recalled



Luscomb's letter "telling me she had received the Grand Bostonian Award from Kevin White. She wrote that if it hadn't been for Melnea Cass (a black community leader) sitting there on the platform, she would have been embarrassed to have been seen with the pack of thieves who were getting awards along with her."

Luscomb lived in cooperative houses from the late 1940s to the late 1970s, "I tried living by myself," she said in a *Tech Talk* interview, "but it was inhuman. I'd come home to a dark house and there'd be no one to share ideas with when I was home." In 1975, at the age of 87, she lobbied hard for legislation to legitimize communal living groups in Massachusetts; they had previously been considered "lodging houses" rather than "family units" and were illegal in residential zones.

"When Florence said she was interested in moving in, we invited her over for a suppertime interview, as was our usual practice," Brown recalled. "One of the people in the house was late to supper, and he could not figure out why someone's grandmother was being asked how many years she had lived in a co-op house before, and could she cook for 12 people or so, and what tasks could she do in a co-op house.

"She had, as we found out later, already been rejected by several co-op houses because of her age," Brown continued. "So Florence came armed with her resume to show that she was not here to interfere in somebody's life. She had her own life to lead, she had her own organizations to work with, she had some commitments."

Around the dinner table, after she moved in, Luscomb recounted the struggles of women for equality, and Brown kept her up to date on the political oppression in southern Africa. The two women went to demonstrations together during the Soweto rebellions in the late 1970s.

Luscomb remained an intrepid mountain climber and vegetable gardener into her eighties. She traveled around the world—"she went to China before it was chic, and her architect's eye helped her take beautiful slides there," her friend Paula Doress said. She lived to see the Women's Center at Salem College named for her, and her archives are preserved in the Schlesinger Library at Radcliffe.

Could Not Retire While She Lived

The memorial service for Florence Luscomb was held December 8 at the Arlington Street Church, a few blocks away from M.I.T.'s old Back Bay campus. It was a joyous occasion; Judge Shubow called it "a retirement party. She wouldn't retire—she couldn't retire—while she was alive." The church was filled with Luscomb's friends and co-workers, who gave speeches, read Luscomb's poems, and sang songs from the suffrage movement. The church balconies were hung with flags from Luscomb's causes: the Progressive Party, the nuclear disarmament movement, the women's movement, the unions. And among the banners was the Class of 1909 reunion pennant from M.I.T., where, she used to tell her friends, her first year at college had been "one of the happiest" in her life. □

PHOTO: BOSTON GLOBE

I CIVIL ENGINEERING

Professors **Yosef Sheffi,** Ph.D.'77, of M.I.T. and **Warren Powell,** Ph.D.'81, of Princeton have completed a computer-assisted load planning model called APOLLO to schedule complex flows of less-than-carload freight traffic. The project was sponsored by the trucking firm of Ryder/P.I.E. Nationwide, seeking a way to most efficiently use its 300 truck terminals and transfer points. Sheffi now seeks additional problems involving complex network analysis combined with operations research and computer-aided design.

S. Shyman Sunder, Sc.D.'81, associate professor in the department at M.I.T., now holds the Gilbert W. Winslow Career Development Professorship to recognize "outstanding accomplishments in teaching and research." Sunder is an expert in Arctic construction and the interactions between ice and human-made structures.

Wayne Huber, Ph.D.'69, professor of environmental engineering sciences at the University of Florida, has been given the Florida Engineering Society's 1984-85 Outstanding Technical Achievement Award. Huber was recognized for his contributions in the field of water resources and hydraulics. . . . **Matthew J. Gordon,** S.M.'82, writes, "After three years as a hydrogeologist with the U.S. Nuclear Regulatory Commission, I recently took a position as an associate engineer with Environ Corp., Washington, D.C., consultants in health and environmental science."

Pierre Haren, Ph.D.'80, writes from Antibes, Frances, that he heads a project systems applied to engineering design. His team of nine researchers and graduate students are engaged in the implementation of expert systems for breakwater design, preliminary satellite design, and building design. Haren is married and has one daughter, Pauline. . . . **John H. Nath,** Ph.D.'67, professor of civil engineering at Oregon State University, Corvallis, has won the $400 1985 American Society of Civil Engineers John G. Moffat-Frank E. Nichol Harbor and Coastal Engineering Award. He was cited for his research on wave-induced forces on cylinders roughened by attached marine structures, improving engineers' ability to estimate design loads. . . . **Irwin J. Kugelman,** Sc.D.'63, was named chairman of the Civil Engineering Department at Lehigh University effective last September. . . . **Erman A. Pearson,** 'Sc.D.'49, of Lafayette, Calif., who taught in the Division of Hydraulic and Sanitary Engineering at the University of California, Berkeley, passed away on August 31, 1985; no further details are available.

II MECHANICAL ENGINEERING

The goal of automated deburring for aircraft engine parts is moving closer, according to **John Hsia,** '53, and **Bruce M. Kramer,** '70, who are working together on a program sponsored by General Electric's Aircraft Engine Business Group. GE says U.S. industry now spends nearly $4 billion a year for burr removal—all done manually. Automation is difficult, says Kramer: deburring is an edge process, not a surface one; burr shapes and locations are unpredictable; and extreme precision is required in many applications. Hsia and **David M. Dombrowski,** S.M.'83, are working on the project in the advanced manufacturing engineering section at GE's Lynn, Mass., works; Kramer, who was a member of the M.I.T. faculty until last fall, is now professor of mechanical engineering at George Washington University.

Three members of the M.I.T. community received honors at the 1985 Winter Annual Meeting of ASME in Miami Beach: **Klaus Jurgen Bathe,** professor of mechanical engineering at M.I.T., the Gustus L. Larson Memorial Award for "outstanding achievement within 10 to 20 years after graduation"; Professor Emeritus **Milton C. Shaw,** who now teaches at Arizona State University, the ASME Medal "in recognition of his international reputation as an eminent engineer and distinguished educator"; and Professor **Theodore H. H. Pian,** Sc.D.'48, of the M.I.T. Department of Aeronautics and Astronautics, ASME honorary membership for "outstanding contributions to the advancement of mechanical engineering science in the areas of structural mechanics and finite element analysis." A fourth major ASME prize had previously come to Professor **Ernest Rabinowicz** of M.I.T.: the Mayo D. Hersey Award, presented at a tribology conference in Atlanta. The award recognizes advances in lubrication science and engineering, and Rabinowicz was cited for 25 years of work in friction and wear phenomena.

To Professor **Richard L. de Neufville,** '60, chairman of the M.I.T. Technology and Policy Program, and **David Shpilberg,** '72, partner in Coopers and Lybrand, New York, the 1985 Alpha Kappa Spangler Award from the American Risk and Insurance Association; the award honors the best paper in the field of risk and insurance during the past decade.

Adjunct Professor **Ernesto E. Blanco** of the department at M.I.T. won the department's 1985 Jacob P. Den Hartog Distinguished Educator Award for "excellence in teaching that has fostered the development of physical insight and engineering judgment." Blanco is president of Universal Textile Machine Corp., Boston, and technical director of the Ophthalmic Division of Acutex Microsurgical, Inc., Norwood; he is known for achievements in machine design.

John W. Carson, Ph.D.'71, a specialist in the field of flow of solids, has been elected president of Jenike & Johanson, Inc., North Billerica, Mass., a consulting engineering firm. Carson joined the firm in 1970 and since has held a variety of research and management positions, authored more than 25 articles, and lectured worldwide on his specialty, the flow of solids. . . . **Erwin Loewen,** Sc.D.'49, has been appointed vice-president of research, development, and engineering for the Analytical Products Division of the Milton Roy Co., Rochester, N.Y., formerly a division of Bausch & Lomb. Lowen joined Bausch & Lomb in 1960; his specialty is in the fields of metrology and diffraction gratings. . . . Two alumni have made news in ASME: **Fred Landis,** Sc.D.'49, professor of mechanical engineering at the University of Wiscon-



You may have thought it was the metric system, but you stand corrected by Stanislav R. Jakub, S.M.'70—the proper name is* systeme internationale, *of which the abbreviation in all languages is SI. He should know: designated by the U.S. Metric Association a certified advanced metrication specialist, Jakub conducts training programs on the application of SI to the needs of mechanical engineers for his colleagues at Stanadyne, Inc., Hartford, Conn., and for countless other audiences. Jakub is also USMA regional manager for Connecticut, New York, and Rhode Island. SI was created in 1960 by a revision of the metric system to embrace all systems of units used in industrial nations.

sin, Milwaukee—named vice-president of professional development; and **Charles A. Berg,** Sc.D.'56, professor and chairman of the Mechanical Engineering Department at Northeastern University, Boston—named a fellow.

Mark C. Sellnau, S.M.'81, writes, "I'm continuing applied research on high-efficiency gasoline engines, in the Engine Research Department, General Motors Technical Center . . . building not only most efficient, but also most powerful (specific power) engine for automotive use." . . . **William H. Foley, Jr.,** S.M.'65, of Arlington, Tex., passed away on October 18, 1985; no further information is available.

III MATERIALS SCIENCE AND ENGINEERING

A $75,000 planning grant for research on the art of preColumbian America and precolonial Africa came to the Center for Materials Research and Ethnology at M.I.T. late last year from the J. Paul Getty Trust of Los Angeles. The new research, combining archaeology, anthropology, art history, and materials science, will begin later this year, and additional Getty grants are anticipated for three or four years' work, according to Professor **Heather Lechtman,** director of CMRAE. Eight Boston-area institutions participate in CMRAE, which is housed at M.I.T.

Donald O. Bolger S.M.'85, reports that he is a steelmaking metallurgist for McLouth Steel Products, residing in Gibraltar, Mich. . . . **Thomas R. Clevenger,** Sc.D.'61, writes from Tokyo that his consulting business, TRC Associates, continues to prosper. "After three years here in Tokyo," he says, "I find that my client list is varied and includes Japanese, Korean, and New Zealand firms, as well as Americans. Life in Tokyo continues to agree with the family, though my youngest son tells me life on M.I.T.'s East Campus isn't so bad as he enters his second year in Course VII." . . . **Winston W. Liang,** Sc.D.'76, has recently been promoted from senior project manager to manager of advanced industrial materials and components at Gas Research Institute, Chicago. Liang is responsible in two project areas: advanced heat transfer systems and industrial materials and components; both are part of GRI's Industrial Utilization R&D Department. . . . **John A. Fellows,** Sc.D.'42, of Glendale, Calif., who worked as a metallurgy consultant in Los Angeles, passed away on October 19, 1985; no further details are available.

IV ARCHITECTURE

Luis Roberto Chavez Fernandez, M.A.A. '76, director of national urban planning in Nicaragua, made newspaper headlines when he returned to M.I.T. last spring to lead a student workshop on the development problems of his adopted country. "I'm very excited about the results," Chavez told the *Boston Globe*—especially the students' ability to "come down from the very sophisticated studies done in academic circles to the very simple, quick-and-dirty approach to getting things done." Noting the rapid growth of Nicaraguan cities, the students proposed new agricultural and industrial production and stable housing in Nicaragua's interior, a coast-to-coast highway, and a deep sea harbor on the Atlantic coast.

Two notable honors for Professor Emeritus **Lawrence B. Anderson,** M.Arch.'30: the Boston Socley of Architects' first Award of Honor, for "many outstanding contributions to architecture and to the profession: as an architect, as an educator, and as an advisor"; and the 21st annual St. Botolph Club Foundation Award, given for "excellence in architecture." Though retired to his home in Lincoln, Mass., Anderson continues to lecture at M.I.T. and to advise the architecture faculty on curriculum changes.

Kate Dundes, M.Arch.'80, reports that she is "principal of her own architectural design firm—Kate Dundes Design—located in New York City—specializing in commercial and residential work." . . . **Kenneth L. Kantor,** S.M.'79, has been appointed to the new position of director of Advanced Development and Research for Teledyne Acoustic Research, Norwood, Mass. Kantor is directing the firm's research and development activities worldwide. . . . **Richard K. Renner,** M.Arch.'76, has been appointed visiting lecturer in environmental studies at Bowdoin College, Brunswick, Me.

Everett A. Glendening, M.Arch.,'54, writes that he has completed two design assignments for the University of Cincinnati — a $12-million geology-physics-science research building and a $9-million Law School building. . . . **Todd L. Siler,** S.M.'81, reports, "My many art exhibitions, publications, and related work make 'living' extra special . . . sure beats course work at M.I.T.!" **Gregory Garcey,** S.M.'82, is working in computer graphics and computer music at Spinnaker Software, Cambridge. . . . **Josephine O. Adams,** M.Arch.'80, is a principal architect for the Newark (N.J.) Housing Authority. . . . **Margo Jones,** M.Arch.'76, recently opened her own architecture practice in Greenfield, Mass., and reports that she is very busy.

A new biographical movie about physicist Niels Bohr was completed last year by Professor **Richard Leacock** and **Glorianna Davenport** of the Film and Video Section in the M.I.T. Media Laboratory, and its showing was a special feature of the Niels Bohr Symposium of the American Academy of Arts and Sciences in November in Cambridge.

William L. Rawn, M.Arch.'79, is one of the heros of *House* (Houghton Mifflin, 1985), a new book by author Tracy Kidder. Rawn is the architect of a house whose construction is the theme of Kidder's book; he is portrayed as "a 'contextualist' who forsakes the intrusive shapes of modernism for structures that blend with a community's character and history," writes reviewer R. Z. Sheppard in *Time*.

To Professor Emeritus **Gyorgy Kepes,** the George Washington Award Medallion of the American Hungarian Foundation. Kepes, born in Hungary, came to the U.S. in 1937 and to M.I.T. in 1946 to become a noted painter, designer, author, and educator—a pioneer in realizing the convergence of art and science.

Hewlett-Packard Co. is giving equipment and software valued at $5 million to the new M.I.T. Media Laboratory for use in its studies of artificial intelligence applied to computer music, graphics and animation, video, and speech processing. Professor **Nicholas P. Negroponte,** '66, Media Laboratory director, says the gift is "an important recognition of media technology's position in the mainstream of advanced research in computer science. . . . The human interface with computers is one of the, if not the, most pressing problems in computing."

Norman D. Day, M.Arch.'58, writes, "After many years as a principal in the architectural and planning firm of Kopple, Sheward and Day, I formed an independent practice in the fields of urban design and planning in 1984—Norman Day Associates, Philadelphia. The firm serves a diversified mix of public and private clients throughout New Jersey, Pennsylvania, Maryland, and Deleware. In addition to my professional practice, I continue to play a central teaching role in the joint master's program in urban design at the University of Pennsylvania, where I have been a member of the standing faculty since 1966." . . . **Mark W. Vande,** M.Arch.'70, has formed his own architectural firm—Vande Associates, in a renovated store-front building in Palmyra, N.Y. . . . **Lois J. Champy,** M.Arch.'71, has joined Bruner-Cott and Associates, Inc., architects, Cambridge.

Walter S. Brodie, S.M.'34, a retired architect and designer of many public school buildings in Massachusetts, passed away in Marblehead (Mass.) on January 20, 1985. Following graduation, Brodie joined the Boston-based firm of Kilham, Hopkins and Greeley, becoming a partner in 1945. He assisted in the design of the Taunton Army Camp, which housed 20,000 soldiers during World War II. Brodie's latest position, prior to retirement in 1984, was at H.M.F.H. Architects, Cambridge.

V CHEMISTRY

William R. Moser, Ph.D.'64, who is professor of chemical engineering at Worcester Polytechnic Institute, served as president of the New England Catalysis Society in 1985. . . . **Mark A.K. Patterson,** Ph.D.'82, reports, "After four years of applied microbiological research with Texaco, Inc., I have returned to school: I am working on my M.D. degree at Albany (N.Y.) Medical College in the class of 1989 and hope to go into academic medical research upon completion of the degree."

Robert W. Ashworth, Ph.D.'77, formerly with the CIBA-GEIGY Pharmaceuticals Division, has joined Knoll Pharmaceutical Co., Whippany, N.J., as director of regulatory affairs. . . . **Virginia R. Cross,** Ph.D.'76, is working in catalysis as a staff chemist at Exxon Chemical, Baytown, Tex.

VI ELECTRICAL ENGINEERING AND COMPUTER SCIENCE

The 1984 Journal Award of the Society of Motion Picture and Television Engineers has come to Professor **William F. Schreiber,** who directs an advanced television research program at M.I.T. The award recognizes Schreiber's paper on "Psychophysics and the Improvement of Television Image Quality" published in the *SMPTE Journal*.

Gregory S. Lauer, Ph.D.'80, is currently working on large-scale packet radio networks at BBN Communications Corp., Cambridge. . . . **Ko Muroga,** S.M.'54, writes, "After seven years in the United States (most recently as president and chief executive officer of NEC America, Melville, N.Y.), I am returning to Japan. It has been a challenging but rewarding experience, and I am grateful for the time I spent at M.I.T. a little more than 30 years ago." Muroga will become associate senior vice-president of the overseas operation of NEC Corp., Tokyo.

Howard D. Hillman, S.M.'60, recently became director of management information systems for the Interface Group, Needham, Mass., the leading producer of computer conferences and expositions. . . . **James S. Linnell,** S.M.'80, has been promoted to supervisor at AT&T Bell Laboratories, Holmdel, N.J., where his current project is lightwave video teleconferencing. . . . **Burton J. Smith,** Sc.D.'72, former vice-president of research and development of Denelcor, Inc., Aurora, Colo., is now a fellow of the new Supercomputing Research Center of the Institute for Defense Analyses, Lanham, Md.; he and his family live in Potomac, Md.

Roger R. Schell, Ph.D.'71, reports that he is one of the founders of Gemini Computers, Inc., Carmel, Calif., where he is vice-president for engineering, responsible for the design and production of a family of highly secure multiprocessing computers.

Thomas J. Lynch, S.M.'59, has recently published *Data Compression Techniques and Applications* (Van Nostrand Reinhold, New York, 1985). This book is an outgrowth of a short course on data compression that Lynch has been teaching at George Washington, University since 1976.

Palmer Derby, '44, retired vice-president and director of new business analysis at Raytheon Co., Lexington, Mass., passed away on June 23, 1985. Derby held various positions with Raytheon since 1942, he had received 24 patents in the U.S. and 33 abroad in microwave technology. . . . Two deaths have been reported to the Alumni Association, with no further information available: **Michael Vincent Bogda,** S.M.'66, of Woodland Hills, Calif., on May 22, 1983; and **Robert S. Lovett,** S.M.'50, former manager of licensing and government affairs at the du Pont Co., Wilmington, Del., in June 1984.

VI-A Internship Program

On December 6, 1985, at a gala celebration (*see page A11-A13*), the completely refurbished Building 39 was dedicated as the **Gordon Stanley Brown** ('31) Building. This building now houses the EECS Department's latest facilities in the area of microelectronics and will serve as the cornerstone of interdisciplinary activity in microsystems development. Many alumni will remember Building 39, built back in 1967, as housing M.I.T.'s Information Processing Center.

A dinner honoring Professor Brown was held in the M.I.T. Museum the evening prior to the dedication. Eight people were asked by Master-of-Ceremonies Professor **Richard B. Adler,** '43, to give short after dinner reminiscences of their association with Professor Brown. VI-A Internship Director **John A. Tucker** was one of these honored and spoke of the days in 1956 when he came to M.I.T. as Professor Brown's assistant, when Brown was head of the department. Others speaking included **Priscilla K. Gray,** speaking for President **Paul E. Gray,** '54, who was unable to attend; **Katherine S. Hazen,** widow of the late Dean **Harold L. Hazen,** '24; Professor **Fernando J. Corbató,** '56, (associate department head, computer science and engineering); Professor Emeritus **Robert M. Fano,** '41; Professor **Francis Reintjes** (former head of the Servomechanisms Laboratory); and Professor **Louis D. Smullin,** '39 (past department head).

Director Tucker was invited by E.I. du Pont de Nemours, Inc., to speak in October on co-operative programs in general and VI-A in particular to executives and managers of the corporation. Du Pont is considering becoming involved in this type of engineering education. Mr. Tucker's Yale Graduate School roommate, Victor E. Mello, a senior consultant in du Pont's Engineering Department, Wilmington, Del., arranged for the talk. Several alumni were present, including: **Francis F. Huppe,** '59 and **John C. Ufford,** '75.

At the December 1985 VLSI research review three VI-A graduate students doing doctoral work presented papers: **Denice D. Denton,** '81, **Wai L. Lee,** '83, and **Jon P. Wade,** '83. Wade was honored last fall with the Digital Equipment Corp. Fellowship, a continuing fellowship first established at M.I.T. for the academic year 1982-83. A VI-A graduate attending the VSLI conference was **A. George Foyt, Jr.,** '59, representing United Technologies Research Center.

The Tech carried the names of three current VI-A students serving on official Institute committees: **Russell M. Basch,** '86 (Wellesley-M.I.T. Joint Committee); **Stephanie L. Scheidler,** '85 (Corporation Joint Advisory Committee); and **Robert J. Webster, Jr.,** '87 (Committee on the Visual Arts).

At a Sunday morning "community hour" following a church service at which he served as Lay Reader, John Tucker was both surprised and pleased to have **Philip H. Peters,** '37, come up and speak to him. Mr. Peters was VI-A with General Electric, knew Professor Timbie (early VI-A director for 28 years), and knows Professor (Emeritus) **Karl L. Wildes,** '22 (Timbie's VI-A assistant). He was also honored by being selected a Tau Beta Pi Fellow.

Two telephone calls are of interest. While at his company's New York offices **Lester A. Gimpelson,** '57, called. He is stationed with ITT in Brussels, Belgium. From San Diego, we heard from **John J. Fratamico, Jr.,** '79.

Our VI-A Office visitor list since last writing includes: **Vincent W.S. Chan,** '71, group leader at Lincoln Laboratory; **Dean R. Collins,** '58, with TI/Dallas; **Chester M. Day, Jr.,** '57, with Bellcore, Morristown, N.J.; **Steven K. Ladd,** '81, product engineering manager with Megatest Corp., Santa Clara, Calif; **Karl M. J. Lofgren,** '75, wife **Christine (Plapp) Lofgren,** '75 and young daughter Ester Ruth—Karl is chief scientist at Western Digital, Irvine, Calif., and Christine is in a Ph.D. program at the University of California, Irvine; and **Karl A. Nyberg,** '80, president of Grebyn Corp., Vienna, Va. **Robert H. Kingston,** '47, of Lincoln Laboratory, who is an adjunct professor in EECS teaching 6.013—Electromagnetic Fields and Energy—now has a desk in the VI-A suite.—John A. Tucker, Director, VI-A Internship Program, M.I.T., Room 38-473, Cambridge, MA

An Income Tax That Taxes Income

While Congress was noisily debating income tax reform last year, Lt. Col. John A. Mathews, S.M.'30 (USAF—Ret.) was perfecting and promoting a uniquely simple progressive tax plan of his own devising. Mathews' proposal follows six principles:

☐ For tax purposes, define income as an increase of wealth minus the cost of acquiring that increase.

☐ Eliminate exclusions, exemptions, and deductions. They are what Mathews calls "upside-down subsidies—their values increase as incomes increase, (making them) incompatible with a progressive income tax system."

☐ Eliminate all corporate income taxes. Instead, require corporations to allocate income periodically to shareholders for taxation as individual income.

☐ Tax individuals only, eliminating the preferential rates now accorded to married couples filing jointly. Such preferential rates are also an "upside-down subsidy," says Mathews; the benefit increases as income increases.

☐ Waive, reduce, or defer tax liability for those whose incomes are below the official poverty level. (The present policy of exempting minimal income from taxation is another "upside-down subsidy," says Mathews.)

☐ Levy taxes in such a way that "the distribution pattern of after-tax incomes would be similar to that of before-tax incomes."

Mathews would eliminate the rules that exclude a portion of capital gains from taxation. Considered an incentive to investment, he says, those provisions are in reality another "upside-down subsidy" of special advantage to high-income taxpayers. Deduction of home mortgage interest, an incentive to home ownership, is also an "upside-down subsidy."

Mathews says his proposal would result in greater simplicity as well as fairness, making taxpaying easier for everyone and its administration easier for the government and Congress. ☐

VII BIOLOGY

Two of the first 16 Markey Scholar Awards in health sciences and medicine of the Lucille P. Markey Charitable Trust have come to **Bradley T. Sheares,** a post-doctoral fellow studying the role of glycoproteins in cell physiology in the Center for Cancer Research. The award carries $500,000 to $600,000 in support over six to eight years. . . . **Alexander Rich,** professor of biophysics in the department at M.I.T., has been elected to a three-year term as a councilor to the National Academy of Sciences.

Professor **Philip Sharp,** who is credited with major research results in the field of gene regulation, is now director of the M.I.T. Center for Cancer Research. He succeeds Professor **Salvador E. Luria,** who retired on May 1 after heading the center for its first 12 years of operation. Sharp will continue the Center's emphasis on virology, immunology, and cellular biology.

William G. Quinn, Jr., who came to M.I.T. a year ago to be associate professor of neurobiology, has won a $100,000 McKnight Neuroscience Development Award to support his research into the mechanisms underlying learning and memory. The McKnight Foundation made 14 three-year grants to advance understanding of memory processes and the disorders that affect them.

VIII PHYSICS

Three plasma researchers at M.I.T. have shared with colleagues at Princeton and Kyoto University, Japan, the Award for Excellence in Plasma Physics Research of the American Physical Society's Division of Plasma Physics. Those honored at M.I.T.: **Stanley C. Luckhardt,** research scientist at the Plasma Fusion Center; Professor **Miklos Porkolab** of the physics faculty; and **Jack J. Schuss,** '73, now at Raytheon. They were honored, in the words of APS, for "the experimental demonstration of start-up, ramp-up, and sustainment of torodial currents by lower hybrid waves."

David Hobbs, S.M.'54, has been promoted to director of new product development for the components division of M/A-Com, Inc., Burlington, Mass. A great deal of Hobbs' 30-year career in microwave component engineering and development has been with M/A Com, serving in various positions—most recently, operations manager of the magnetron group. . . . **Harvey S. Picker,** Ph.D.'63, has been promoted to professor of physics at Trinity College, Hartford, Conn. . . . **Mortimer M. Elkind,** Ph.D.'51, is currently chairman of the Department of Radiology and Radiation Biology at Colorado State University, Ft. Collins.

Nelson L. Alpert, Ph.D.'48, reports his latest activities: a member of the International Federation of Clinical Chemists Expert Panel on Instrumentation, and of the College of American Pathologists' Instrumentation Resource Committee; editor of *Clinical Instrument Systems;* and active in the area of market research and consulting on clinical and analytical instruments. . . . **William A. Seidler,** Ph.D.'72, is currently a principal scientist in government research at Jaycor, San Diego, Calif. He holds several IEEE conference awards for his papers, served as guest editor to the IEEE in radiation effects technology, and was technical program chairman of the 1985 Hardened Effects and Radiation Technology Conference.

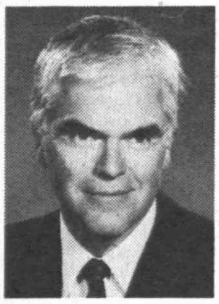
John E. Mekota, Ph.D.'50, reports from Waltham, Mass., "I am consulting in computer usage and programming and am very busy, thank

God!" . . . **John K. Galt,** Ph.D.'47, reports that he received the IEEE's Frederick Philips Award. . . . **Merrill Andrews** Ph.D.'68, has been appointed to chair the Department of Physics at Wright State University, Dayton, Ohio. Andrews joined the WSU faculty in 1970 as assistant professor of physics, and has been director of the Engineering-Physics Program since 1974.

Robert J. Ledoux, '78, whose research field is heavy-ion physics, now holds a Cecil and Ida Green Development Professorship, the result of a $1-million gift to M.I.T. from Mr. and Mrs. **Cecil H. Green**. It's the latest in a long series of benefactions by the Greens; Cecil Green studied electrical engineering with the class of 1923 and went on to become co-founder of the predecessor company of Texas Instruments, Inc.

Paul A. Fleury, Ph.D.'65, director of the Physical Research Laboratory at AT&T Bell Laboratories, has received the Michelson-Morley Award, the highest scientific honor awarded by by the Case Institute of Technology. Fleury's major contribution has been through his advancement of the science and technology of optical communications . . . his research group was instrumental in creating light pipes or optical glass fibers that carry large amounts of information over long distances by laser light.

Professor **Toyoichi Tanaka** of M.I.T. was 1985 recipient of the Nishina Memorial Prize, the highest award given in the Physical Society of Japan. Tanaka was honored for his work on phase transition and critical phenomena of polymer gels, showing that such gels undergo large changes in volume upon small changes in temperature, solvent composition, and electric field. Tanaka's findings suggest the use of gels as switches, memories, display units, selective absorbants, and mechanical actuators for robots and artificial muscles—a lively research arena.



H. Mark

Hans Mark, Ph.D.'54, chancellor of the University of Texas System, has been named a member of the board of trustees of the Mitre Corp., Bedford, Mass. Mark became chancellor of UT in 1984, having previously served as deputy administrator of NASA (1981-84) and secretary of the Air Force (1979-81.)

John W. Lindner, Jr., Ph.D.'57, adjunct professor of physics at California State University, Long Beach, who was manager of the Systems and Integration Laboratory at TRW Systems, passed away in Los Angeles on August 31, 1985. Lindner, whose death was the result of a massive heart attack, had been a physicist and administrator for 27 years at TRW Space and Technology Group.

Theodore R. Steger, Jr., Ph.D.'74, director of exploratory and fundamental research in the Polymer Products Division of the Monsanto Co., Springfield, Mass., passed away on March 1, 1985. Employed with Monsanto for 11 years both in St. Louis and Springfield, Steger was also a member of Phi Beta Kappa. . . . **John W. McNall,** Ph.D.'42, of Greensburg, Va., passed away on July 10, 1984; no further details are available.

John Mapes Houston, Ph.D.'55, a retired physicist who was formerly manager of the Engineering Physics Branch at the General Electric Research and Development Center, Schenectady, N.Y., passed away on August 31, 1984. Houston spent his entire working career at GE (until his retirement in 1983), managing several of the center's research branches. Under his direction, GE scientists made a number of significant innovations in the areas of solid-state physics, physics, and plasma diagnostics. Also, Houston was author of some 40 technical papers and held 32 patents. . . . **Ralph W. McKenney, Jr.,** S.M.'67, a medical doctor from Staten Island, N.Y., passed away in January 1985.; no further information is available.

X CHEMICAL ENGINEERING

Alan S. Michaels, Sc.D.'48, an independent industrial consultant and adjunct professor of chemical engineering at M.I.T. and Lehigh University, was the 1985 winner of the American Chemical Society's Award in Separations Science and Technology, sponsored by the Rohm and Haas Co. The award was in recognition of Michaels' work in a variety of areas of separation science, specifically his research leading to "important improvements in developments of artificial kidneys and organ components, sea water desalination, oil recovery . . . and time-release drug systems." . . . **Allan S. Hoffman,** Sc.D.'57, professor in the Center for Bioengineering and Department of Chemical Engineering at the University of Washington, Seattle, received the 1984 Clemson Award for Outstanding Contributions to the Scientific Literature of Biomaterials at the Second World Congress of Biomaterials in Washington, D.C. Hoffman served as president of the Society for Biomaterials (U.S.) in 1983-84. **Edward A. Mason,** Sc.D.'50, vice-president—research of Standard Oil Co., has been elected for six years on the Corporation of the Woods Hole Oceanographic Institution.

Barry R. Brofin, Sc.D.'60, is co-founder, chairman and president of Scientific Leasing, Inc., Farmington, Conn. The firm was founded in 1968 and is rapidly expanding. A "home-grown" success story, the firm leases high-technology equipment to two major markets—hospitals and research—and development industries. "We're converting a successful high-tech leasing company from an Eastern firm to a nationwide firm," Brofin told the *Hartford Courant*.

Edward G. Najjar, S.M.'56, has been promoted from executive vice-president of nitroparaffins and technology to corporate vice-president and president of the Organic Chemical Division at W.R. Grace & Co., New York City. . . . **George A. Soffer,** Sc.D.'50, reports that effective March 1, 1985, he was appointed manager of customer engineering services at Exxon Nuclear Co. and will be moving to Bellevue, Wash., Exxon's headquarters.

Professor **Janos Beèr**, scientific director of the M.I.T. combustion research facility, has been awarded the Melchett Medal of the London-based Institute of Energy. The medal was awarded at a special ceremony, where he presented his lecture: "Clean Combustion of Coal, Research and Applications." . . . **Michel L. Besson,** S.M.'60, president and chief executive officer of Certain-Teed Corp., Valley Forge, Penn., has been elected a director of the Square D Co., Palatine, Ill. . . . **Pablo G. Debenedetti,** Ph.D.'84, has been appointed assistant professor of chemical engineering at Harvard University. Debenedetti's research interests include thermodynamics, statistical mechanics, transport phenomena, kinetic theory, and computer modeling of matter.

Robert L. Slifer, S.M.'50, has been named president of Montelle Vineyards, Augusta, Mo. Slifer joined the firm in 1980, after taking early retirement from Monsanto, where he had been a project engineer in South America, Europe, and the U.S. . . . **Edward G. Najjar,** S.M.'56, has been elected a corporate vice-president at W.R. Grace & Co. and president of its Organic Chemicals Division, Lexington, Mass. Najjar has been with the firm since 1959, most recently serving as executive vice-president of nitroparaffins and technology and development for the Organic Chemicals Division. . . . **Robert L. Mitchell,** S.M.'47, vice-chairman of the Celanese Corp., New York City, has been appointed to Chrysler Corporation's new Technology Advisory Council.

Three deaths have been reported to the Alumni Association, with no further information available: **Annis G. Asaff,** Ph.D.'37, of Lincoln, Mass., in March 1983; **Peter Kolupaev,** Sc.D.'37, of Philadelphia, Penn., on January 1, 1983; and **Edward J. Fradkin,** S.M.'46, of New York City, while on vacation in Mexico on February 10, 1985.

XI URBAN STUDIES AND PLANNING

Frederick L. Merrill, Jr., M.C.P.'80, has been named an associate of Sasaki Associates, Inc., Watertown, Mass. Merrill has been with the firm since 1983 and his current work includes the Town Lake Alternative Evaluation Study of the City of Dallas and the Metropolitan Corporate Center Master Plan for Metropolitan Life Insurance Co. in Malborough and Northborough, Mass. . . . **Ramon C. Bacani,** M.C.P.'79, reports, "I am working for the government, in the area of public enterprise monitoring and review."

John H. Larson, M.C.P.'55, has been promoted from vice-president of finance to president and chief executive officer at the Connecticut Energy Corp., Bridgeport.

Father **Robert G. Howes,** M.C.P.'60, is director of the Office of Diocesan/Denomination Liaison for Morality in Media (a New York City-based group). Father Howes, a specialist in church planning, is a founding member of the National Catholic Pastoral Planning Conference, a charter member of the American Institute of Certified Planners, as well as national coordinator for Citizens for Public Prayer. . . . **Stephen A. Klein,** reports, "I am working as staff counsel to Massachusetts State Senator George Bachrach (D-Watertown). During the past year a major legislative success was a package to rehabilitate abandoned housing." . . . **Carol J. Spack,** M.C.P.'81, writes, "I am working my little fingers to the bone as an attorney in Boston with Sullivan and Worcester."

Following a conference on "Making the Profit System Work for Social Change: The Rouse Approach to Urban Renewal," the Center for Real Estate Development at M.I.T. announced a new study of housing for the poor—"a major attempt at cutting through the cost barrier to housing the poor," says Professor **Phillip L. Clay,** Ph.D.'75, who will be its director. The conference honored James W. Rouse, former chairman and chief executive officer of the Rouse Co., developer of the Faneuil Hall Marketplace in Boston. Rouse is also founder of the Enterprise Foundation, which is supporting a number of innovative efforts to provide housing for the poor. Monitoring and evaluating the programs of the Enterprise Foundation will be an important part of the M.I.T. project, says Professor Clay.

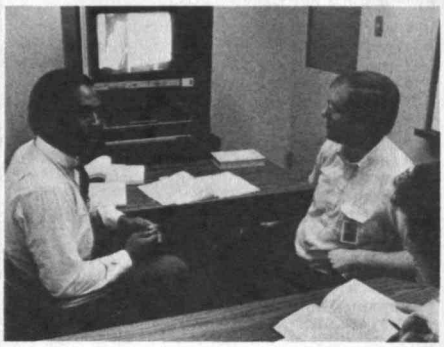
Anne Baron Wilson, a graduate student in the department, has received a $2,000 scholarship in memory of Charles Abrams, administered for its sponsors by the American Planning Association. According to the awards committee, Wilson was cited for her "superior academic achievement and broad interest in social concerns" . . . and her commitment to finding new solutions to low-income housing and public health problems. . . . **Francis T. Ventre,** Ph.D.'73, professor of architecture and director of the Environmental Systems Laboratory at Virgina Polytechnic Institute and State University, Blacksburg, was awarded a grant from the National Endowment of the Arts Design Arts Program to assess the competiveness of the United States in the international market for design services.

Melvin F. Levine, M.C.P.'56, moved his home and work base back to Boston in January 1985. He has provided urban development consulting services to public and private clients in more than

Engineering Education by Satellite and TV



National Technical Univesity students, such as these at Hewlett-Packard, receive courses by television throughout the U.S. NTU's president, Lionel Baldwin, S.M.'55 (left), was honored last fall by the Congressional Institute for Space, Science, and Technology.



Lionel V. Baldwin, S.M.'55, is president of a unique university that has no campus and that gives only master's degrees in only five fields of technology. But his National Technical University, operated from Fort Collins, Colo., where Baldwin was formerly dean of engineering at Colorado State University, is no "diploma mill." It is, a serious professional experiment that is "successfully challenging many of higher education's traditional assumptions about time and place," says Edward B. Fiske in the *New York Times*.

And Baldwin himself was honored late last fall by the Congressional Institute for Space, Science, and Technology for "outstanding leadership in fostering industry/university relationships and training via telecommunications technology."

In a nutshell, NTU is a distributor. It broadcasts by satellite courses given at 19 colleges and universities to some 500 students in companies throughout the U.S. Students take the courses under the auspices of their employers, passing examinations and accumulating credits just as do part-time students in any more conventional university. When they've completed all course requirements they receive NTU degrees.

For the present, NTU offers master's degrees in five areas—electrical engineering, computer science, computer engineering, manufacturing systems, and engineering management. Each area has its own requirements, and engineers admitted to an NTU master's degree program receive guidance from a designated faculty adviser at one of the universities. Together, the adviser and the student determine a curriculum that meets the student's needs.

To obtain a master's degree in computer engineering, for example, a student must complete 30 credit hours of study distributed among what NTU calls "core," "depth," and "breadth" areas. This includes at least eight credits (essentially three courses) in the three general areas of software systems, computer architectures, and algorithms and data structures. The depth requirement demands two courses from each of two areas, for a total of 12 credits. These areas include the three just mentioned and digital design, graphics, intelligent systems, and mathematics and computational methods.

Breadth requirements demand completion of two courses chosen from the areas of business applications, CAD/CAM, communications, control and robotics, electrophysics, mathematics, signal processing, and theory of computing. Finally, each student must take an elective course in any of the categories mentioned, along with a noncredit seminar. The degree candidate may substitute a thesis for the elective course and one depth course.

Many NTU courses are given to off-campus students at the same time they're presented in on-campus classrooms. Some classrooms are equipped so that off-campus NTU students can ask questions in real time, just as resident students do. Where NTU broadcast is not simultaneous, "recitation" sessions are scheduled by teleconferencing. But Baldwin admits that the lack of direct contact between teacher and student is a major concern. He says NTU is developing electronic mail as a way to better link students and teachers.

Companies participating in NTU enjoy the added advantage of having access to the resources of the Association for Media-Based Continuing Education for Engineers, an NTU associate. John T. Fitch, '52, is executive director of AMBCEE, which provides university-produced, technological course and seminars for a nationwide network. □

50 cities since 1975. Levine has done feasibility analyses for Portside in Toledo, Water Street Pavilion in Flint, and 6th Street Marketplace in Richmond—three festival marketplaces developed by the Enterprise Development Co. as public-private joint ventures. . . . **Anthony Mallows,** M.C.P.'81, of Sasaki Associates, Inc., is project manager for Sasaki's work on Virginia Center, a 4-million-square-foot mixed-use development to be built in Fairfax County, Va. **Norris Strawbridge,** (M.Arch.'76) is project architect for the same center. Mallows and Strawbridge both work for Ellenzweig Moore and Associates, Cambridge.

XIII OCEAN ENGINEERING

William C. Gibson, '51, reports, "I am completing my tenth year with Vitro Corporation Projects, Silver Spring, Md., in naval facilities engineering." . . . **Charles N. Payne,** S.M.'48, is currently vice-chairman of Capital Marine Corp., Chester, Penn. Payne was formerly president of Pennsylvania Shipbuilding Co., Capital's subsidiary. . . . **Richard F. Elliott,** S.M.'69, has been named vice-president of manufacturing at H.B. Ives, New Haven, Conn., a manufacturer of consumer and contract builders hardware.

Edward S. Carmick, S.M.'40, summarizes recent activities: "Adjutant in my American Legion post in Palo Alto; retain membership in several World War II submarine veteran organizations; still keep up a big garden; have written nearly five volumes of my 'recollections' (not for publication). Health failing, but still have time for friends and hobbies." . . . **Raphael Vermeir,** S.M.'79; has been transferred to Conoco's U.K. subsidiary as acquisition/merger manager with responsibilities for all North Sea offshore and onshore acreage, as well as other merger/acquisition activities.

Lieutenant **Charles H. Goddard (USN),** Oc.E.'85, and Lieutenant **Udo H. Rowley (USN),** Oc.E.'85, won the Society of Naval Architects and Marine Engineers graduate student paper prize for "Implementation of a Computer-Supported Naval Ship Design System at M.I.T.," presented at the January 24, 1985, meeting of the New England section of SNAME. **George A. Kreizis,** S.M.'86, was awarded the undergraduate student paper prize for "A Computer Code for the Prediction of Two-Mode Response Characteristics of a Marine Riser at Right Angles to a Uniform Strait," presented at the November 19, 1984, meeting of the M.I.T. student section of SNAME.

Professor **A. Douglas Carmichael** in the department at M.I.T. was elected a fellow of the Society of Naval Architects and Marine Engineers at the 93rd annual meeting last November. . . . M.I.T. Professor **Henry S. Marcus,** S.M.'67, is a member of the recently formed Committee on Productivity of Marine Terminals of the Marine Board, National Research Council/National Academy of Sci-

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XIV ECONOMICS

William F. Massy, Ph.D.'60, vice-president for business and finance and professor of business adminstration at Stanford University, has been elected to the board of directors of Diebold, Inc., Canton, Ohio. . . . **Arnold R. Weber,** Ph.D.'58, formerly president of the University of Colorado, is now the 14th president of Northwestern University, Evanston, Ill. Weber, formerly serving as a faculty member at Carnegie-Mellon, Stanford, and M.I.T., is described by his former associate Secretary of State George P. Shultz as "a scholar of quality, with vast experience in higher education and public service.". . . . **Barend A. De Vries,** Ph.D.'52, has left the World Bank and joined the Brookings Institution as a guest scholar. He is studying future patterns of capital flows to developing countries, and the collaboration of official and private sources of finance.

Professor **David McClain,** Ph.D.'74, was named chairman of the Finance and Economics Department in the School of Management at Boston University last May.

XV MANAGEMENT

Linda S. Marks, S.M.'82, describes herself as a "creative gourment," with "custom gourmet desserts." (Her address is available on special application from the editors.) . . . **Robert K. Brauer,** S.M.'79, writes, "Returned to Seattle, Wash. as regional director, airplane promotion for Africa and the Middle East at Boeing Commercial Airplane Co. My favorite languages are nearly useless, but I'm facing more marketing challenges that one could hope for." . . . **Walter W. Schroeder III,** S.M.'70, former assistant vice-president of Midcon Corp., Chicago, Ill., has been promoted to vice-president for corporate acquisition planning.

Frederick E. Mangelsdorf, S.M.'60, of White Plains, N.Y., has been re-elected to the Corporation at the Woods Hole Oceanographic Institution. . . . **Bruce A. Blomstrom,** S.M.'59, an authority in planning, marketing, and international business development, has been elected vice-president of corporate development and an officer at the Whittaker Corp., Los Angeles, Calif. Blomstrom was formerly vice-president of marketing, sales, and planning at Alpha Therapeutic Corp., Los Angeles, and he was previously associated with Abbott Laboratories and Libby, McNeill, and Libby.

T. Grange Simmons V, S.M.'57, reports, "I am vice-president of planning for Mobil Chemical, Stamford, Conn. My two sons are married and my one daughter is currently at Phillips Exeter. I see **Bob Musser,** S.M.'64, as he also works for Mobil." . . . **Stephen W. Winer,** S.M.'65, formerly marketing manager (since 1981) of process chemicals for J.T. Baker Chemical Co., Phillipsburg, N.J., has been appointed business director of the Performance Chemicals Products Group to oversee the commercial development of high-technology products, including advanced ceramics for electronics. . . . **Michael Gauthier,** S.M.'82, is working at Temple, Barker and Sloane, Lexington, Mass., and he and his wife were expecting their first child in May 1985. . . . **Susan Sudman,** S.M.'75, director of the health care consulting practice at Peat, Marwick, Mitchell & Co., St. Louis, Mo., was included in the list of "73 Women Ready to Run Corporate America" in *Working Woman* magazine (April 1985). Prior to her current position, Sudman served as vice-president of consulting services for the 12-state midwest region of Amherst Associates; she has spent 14 years in the field of health care.

Philip R. Marsilius, S.M.'48, president of Producto Machine Co., Bristol, Conn., has been named general chairman of the 1985 United Way Campaign in Eastern Fairfield County. Marsilius will direct the first leg of a three-year drive to reach $5 million.

Sloan Fellows

Thomas A. Young, S.M.'72, is president of the Martin Marietta Aerospace Co. as well as vice-president of the parent Martin Marietta Corp. . . **William O. McCoy,** S.M.'68, vice-chairman of the BellSouth Corp., has been elected director of Liberty Corp., Greenville, S.C. . . . **Joseph H. Vipperman, Jr.,** S.M.'75, former vice-president and controller of the American Electric Power Co., Inc., Columbus, Ohio., has been promoted to executive vice-president for operations. . . . **Robert E. Fenton,** S.M.'77, writes, "I was promoted to captain, U.S. Coast Guard, on April 16, 1984. I'm now chief, Plans and Policy Division, Office of Command, Control, and Communications, U.S. Coast Guard Headquarters, Washington, D.C. I had an article, 'Caribbean Coast Guard: A Regional Approach,' in the March/April 1984 issue of the *Naval War College Review*. Graduated with highest distinction (top five percent of the class) in the 1983 Naval War College class. We have a daughter, Patricia Anne, born on March 19, 1983, in Newport, R.I."

Thomas L. Watts, S.M.'80, has been elected vice-president—labor relations and personnel at Union Pacific System, Omaha, Neb., responsible for directing labor relations and personnel activities on the 21-state railroad.

Richard Sandrock, S.M.'81, is director of business unit strategy for Ameritech, the Chicago-based parent of the Midwest Bell companies. Sandrock began his telephone career with Ohio Bell in 1964, from which he was on leave during his year at Sloan.

A total of 55 mid-career executives are now at M.I.T. with Sloan Fellowships for 1985-86. It's the 54th class since the founding of the program, which now has over 1,500 alumni and alumnae. The new class—47 men and 8 women—came predominantly from American industry. But eighteen come from overseas—Argentina, Canada, England, France, Guatemala, Iraq, Japan, Singapore, Sri Lanka, Taiwan, and Venezuela. Japan has the largest foreign contingent—five fellows.

Denis B. Trelewicz, S.M.'70, is chief financial officer at Dynatrend, Inc., Woburn, Mass., consulting engineers. . . . **F. Duane Ackerman,** S.M.'78, former vice-president for corporate planning and development at BellSouth Corp., Atlanta, Ga., is currently executive vice-president for network planning and marketing at BellSouth Services. . . . **A. Thomas Young,** S.M.'72, has become executive vice-president of the Aerospace Division of Martin Marietta Corp., Orlando, Fla. Formerly he was with Martin Marietta headquarters in Bethesda, Md. . . . **Thornton A. Wilson,** S.M.'53, chairman of the board and chief executive officer at the Boeing Co., Seattle, Wash., received the National Academy of Sciences Award in Aeronautical Engineering last April. Wilson was cited for "bold and farsighted leadership which has enabled this nation to maintain and enhance its preeminence in commercial aircraft." . . . **William R. Thompson,** S.M.'75, is president and general manager of the Field Services Division at the Western Union Corp., Saddle River, N.J.

Senior Executives

Donald R. Clark, '72, has retired as executive vice-president of petroleum products at Conoco, Inc., Wilmington, Del. . . . **E. O. Hartig,** '76, former vice-president for defense and energy operations at Goodyear Tire and Rubber Co., Akron, Ohio, is now vice-president for engineering and research at Goodyear. . . . **Walter R. Boris,** '65, has announced plans to retire this year as executive vice-president of finance and corporate affairs



After nearly 15 years as its first director, Professor Irving M. London (center) retired early last year from leadership of the Harvard-M.I.T. Division of Health Sciences and Technology. Here Professor Roger Mark, '60, of M.I.T. and Dr. William Beck (right) of Massachusetts General Hospital, HST's director of admissions, congratulate London late last fall.

at the Consumers Power Co., Jackson, Mich. . . . **Leland C. McGraw,** '72, is vice-president for information and technology at the Chevron Corp., San Francisco. McGraw was formerly vice-president of Chevron U.S.A., a subsidiary. . . . **John C. Mackeen,** '-83, has been promoted from product group manager to vice-president of Digital Equipment Corp., Maynard, Mass.

Edward J. Mooney, '79, has been promoted from vice-president to senior vice-president of human resources at the Nalco Chemical Co., Oak Brook, Ill. . . . **James D. Harty,** '76, retired in November 1984 as president and chief operating officer of the Raymond Corp., Greene, N.Y. . . . **Joseph A. Baute,** '64, is currently chairman, chief executive officer and director of the Markem Corp., as well as director of the Federal Reserve Bank of Boston. . . . **R.P. Onorati,** '81, writes, "I have assumed command of the Naval Ocean Research and Development Activity (NORDA) in Bay St. Louis, Miss., which has as its primary mission advanced research and development in the areas of oceanography, ocean sciences, technology, and marine sciences."

Management of Technology Program

Geoff Andrews, S.M.'82, writes that their second child, Jonathan, was born on October 29. Congratulations! Geoff is enjoying his new challenge as director of new business development for Pilkington's E-O Division. . . . **Erik Chaum,** S.M.'84, notified us in December he would be starting a new job in January with the Naval Underwater Systems Center in Newport, R.I. It's a technical staff position, doing technology assessment—specifically artificial intelligence technology and applications to submarines.

Peter Drummond, S.M.'85, wrote us in December to say he was settling into his new job with Lucas, a manufacturer of automotive and aircraft parts in Birmingham, England, as sales and marketing manager. He's not far from **Dave Rimmer,** S.M.'85, and invites any would-be vacationers to Britain to come visit.

John Harrison, S.M.'83, has a new position at Parsons Brinckeroff as manager of project control in Newark, N.J. He writes that he and his family have moved into their new house addition and would love to see classmates next time they're near Princeton. He saw **Bob Logcher** (Course I, Sc.D.'62) in Detroit at the ASCE meeting this fall. . . . **Jim Ishikawa,** S.M.'85, joined Wang in September as product manager. He was in Cambridge in November and stopped by for a quick lunch with the current MOT class. Jim is enjoying his three-pronged job, entailing strategic management, design, and contract support.

John Krawiec, S.M.'85, wrote us a long, newsy letter in October. He's working in Utah at Morton Thiokol in their Composite Materials Product Group as group leader for advanced processes. He sounded very happy there and reported that Roz and Anne are settling into their new home as well. Anne is "growing like the national debt!" . . . **John Piret,** S.M.'85, stopped by the office in December. After an extensive visit back to France over the summer and fall, he's back in the U.S. starting a new company that will license and manufacture products in electrostatics using a French technology. He sounded very excited about the prospects but also overwhelmed with the details of starting a new venture, such as tracking down good lawyers, etc. He's sharing a house with his sister here in Cambridge and is currently working out of his home.—Jane Morse, Program Manager, M.I.T., Room E52-125, Cambridge, MA 02139

XVI AERONAUTICS AND ASTRONAUTICS

Joseph Pedlosky, '59, who also holds two graduate degrees from the department, was honored late last spring by election to the National Academy of Sciences. Pedlosky is now senior scientist and Doherty Professor of Oceanography at the Woods Hole Oceanographic Institution.

Wesley L. Harris, who joined the M.I.T. faculty as associate professor in 1972, is now dean of the School of Engineering at the University of Connecticut. Harris is an expert on helicopter rotor dynamics and noise, and he was founding head (from 1975 to 1979) of M.I.T.'s Office of Minority Education.

Melchor L. Suarez, S.M.'77, has been with Northrop's Precision Products Division (Strapdown Systems Analysis Section) since 1985, and is living in Dedham, Mass. . . . **Byron K. Lichtenberg,** Sc.D.'79, writes, "I have been busy starting a consulting firm, Payload Systems, Inc., in Wellesely, Mass., specializing in space-flight operations. My future goal is to help companies get started in space-based R&D and to promote commercialization of space."

Kenneth R. Britting, Ph.D.'71, a mechanical engineer at the Northrup Corp., Norwood, Mass., died unexpectedly on February 18, 1985, at the age of 48. Britting specialized in navigation equipment; was involved in research and development projects at Northrup since 1977; and pre-

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viously was employed at the Draper Laboratories, Cambridge, and the Markie and Sloan Laboratories at M.I.T. He was the author of *Inertial Navigation Systems Analysis*, a text book. . . . Two deaths were reported by the Alumni Association, with no further details available: **William B. Banks,** S.M.'55, of Port Orange, Fla., on Feburary 22, 1985, of cancer; and **John B. Padgett, Jr.,** S.M.'54; of Palos Verdes, Calif., on July 16, 1984.

XVII POLITICAL SCIENCE

Writing in *Foreign Policy* magazine, Professor **Lincoln Bloomfield** of M.I.T. calls on U.S. presidents to de-emphasize their White House staffs when it comes to foreign policy decisions, relying instead on the government's career experts. "The most disturbing aspect of recent presidents' performance," says Bloomfield, "has been their steadily decreasing reliance on professional bureaucracies and on the indispensible knowledge career experts can supply about history, politics, economics, cultural psychology, technology, and the track records of other players in the international game."

News items regarding three faculty members in the department at M.I.T. has reached the *Review* office: Professor **Michael Lipsky** testified before the House Select Subcommittee in Washington, D.C., last September on the role of food banks and community action programs in the federal surplus commodity distribution program, expressing concern about the effects of bureaucracy on the program. Professor **Peter H. Smith** spoke at the Cambridge Forum last October on "Human Rights in Central America." Smith, who recently returned from Mexico and Central America, is co-author of *Modern Latin America. . . . Technologies of Freedom* by the late Arthur Sloan Professor **Ithiel de Sola Pool** (who passed away on March 11, 1984) was named winner of the 1984 Gladys M. Kammerer Award for the best book published on United States national policy during the year. Pool's book, now in its second printing by the Harvard University Press, deals with free speech in an electronic age; the award is made annually by the American Political Science Association.

Two milestones in the career of **Steve R. Pieczenik,** Ph.D.'82, in 1985: his first novel, *The Mind Palace*, was published in October by Simon and Schuster; and his first off-Broadway play, *Goodwill*, opened in New York at the Clurman Theater. . . . **Richard Ashley,** Ph.D.'77, associate professor of political science at Arizona State University, Tempe, received the 1985 Karl W. Deutsch Prize, presented by the International Studies Association, for outstanding international studies research by a scholar under 40 years old. Ashley was cited for his book, *The Political Economy of War and Peace*, and a series of related articles.

XVIII MATHEMATICS

Three members of the department at M.I.T. retired from full-time teaching and research last June 30: Professors **Warren Ambrose, Herman Chernoff,** and **George M. Whitehead.** . . . Ambrose, who arrived at M.I.T. in 1947 to be assistant professor, has taught many courses, but his areas of chief interest are probability theory, differential geometry, and partial differential equations. He was educated at the University of Illinois and before coming to M.I.T. had held teaching posts at Alabama, Princeton, and Michigan. On leave from M.I.T., where he became full professor in 1957, Ambrose worked and taught at the Institute for Advanced Study, the Tata Institute of Fundamental Research (Bombay, India), the Belgian National Research Center, and the University of Buenos Aires. . . . Chernoff came to M.I.T. from Stanford, where he had been professor of statistics and chairman of the department. After completing his Ph.D. at Brown (1948), Chernoff went to Illinois, then to Stanford. He held a variety of visiting assignments—at Columbia, the London School of Economics, the Universities of Rome and Tel Aviv, Hebrew University, and the Japanese Institute of Statistical Mathematics. . . . Whitehead came to M.I.T. in 1949, eight years after finishing his doctorate at the University of Chicago, and he's been a full professor since 1957. Three leaves of absence have taken him to Oxford, Princeton, and the Universities of Manchester and London. Whitehead is a specialist in homotopy—the relationships among similar mathematical expressions.

David Hazen, S.M.'83, has joined the Advanced Systems Group of Aerodyne Research, Inc., Billerica, Mass., as an applied mathematician. Hazen will be working in the area of infrared background and aircraft signature phenomonology.

Louis Robinson, '50, a computer-science expert with the IBM Corp., Armonk, N.Y., for the past 32 years passed away on March 28, 1985. Robinson was responsible for the early development of computers in business and statistical modeling, the application of computers to Braille translation and other innovative uses. Prior to his career at IBM Robinson taught at Syracuse University in the Department of Mathematics. . . . **Charles C. Conley,** Ph.D.'61, of Saint Paul, Minn., passed away on November 20, 1985; no further details are available.

XX APPLIED BIOLOGICAL SCIENCES

A new Center for Bioprocess Separations Research is being developed by Professor **Charles L. Cooney,** Ph.D.'70, under a grant to M.I.T. from Alpha-Laval. It's called the first advanced biotechnology research center for biochemical separations in the U.S., and Cooney says the facilities, due to be ready in January, "will enable M.I.T. to stay in the forefront of biochemical research and help Alpha-Laval meet the challenge of providing state-of-the-art solutions to biochemical process separation problems."

Nevin S. Scrimshaw and **Max Milner** have been installed as fellows of the American Institute of Nutrition. Scrimshaw is Institute Professor at M.I.T., director of the M.I.T./Harvard International Nutrition Program and of the M.I.T. Clinical Research Center. Milner, retired as executive director of AIN, was associate director of M.I.T.'s International Nutrition Program from 1975 to 1980.

Professor **Daniel I. C. Wang,** '59, who is director of a new Center for Biotechnology Process Engineering being established at M.I.T. by the National Science Foundation, was honored late last spring by election to the American Academy of Arts and Sciences.

Robert S. Langer, Sc.D.'74, who was awarded the Dorothy Poitras Chair at M.I.T. in 1982, has been promoted to the rank of full professor. A member of the faculty since 1978, Langer has made pioneering contributions to "controlled release technology" for pharmaceuticals and to medical applications of enzymes.

ChoKyun Rha, associate professor of biomaterials science and engineering in the department at M.I.T., is embarking on a new, comprehensive study of the structures, properties, and functions of biopolymers under a $500,000 three-year research grant from the Department of the Navy. The plan is to assess novel polymers and other materials that can be foreseen with modern biological techniques, including genetic engineering. . . . **William J. Shoemaker,** Ph.D.'71, an authority on brain growth and development, has been named director of the Neurobiology Laboratory in the Department of Psychiatry at the University of Connecticut Health Center, Farmington. Shoemaker will also serve as a member of the Alcohol Research Center in the School of Medicine, participating in studies determining the nature of the addiction. Shoemaker was formerly senior scientist at the Salk Institute, La Jolla, Calif.

XXII NUCLEAR ENGINEERING

Shelby T. Brewer, Ph.D.'73, former assistant secretary of energy for the U.S. Department of Energy, has joined (September 1984) Combustion Engineering's Power Systems Group as vice-president of the Nuclear Power Systems Division. . . . **Donald A. Dube,** Ph.D.'80, has been promoted to senior engineer by Northeast Utilities. He is project engineer for the Connecticut Yankee Nuclear Power Station's (Berlin) probablistic risk assessment effort.

James L. Klucar, S.M.'69, writes, "I recently started my own company—INT, Inc.—offering engineering consultant services to the nuclear power industry in the fields of startup, operations, and refueling outage management." . . . **William T. McCormick, J.R.,** Ph.D.'69, has been selected chairman and chief executive officer of American Natural Resource Co. (ANR), Detroit, Mich. McCormick joined ANR in 1978, after holding a variety of posts with the American Gas Association and the federal government, including The White House Energy Policy Office.

World uranium resources are larger than most estimates of as little as a decade ago, and this fact is "radically changing our outlook about the future availability and price of fuel for conventional nuclear power plants and about the timetable for alternative fission and fusion technologies," says **Thomas L. Neff,** director of the M.I.T. Energy Laboratory's International Energy Studies Program. Neff's analysis is the subject of his book, The International Uranium Market (Ballinger Publishing Co., Cambridge, 1984). It's described as "the first comprehensive book on what is the second largest (but quite secretive) international energy market . . . a systematic examination of the economic, political, and structural forces governing trade in one of the world's most critical resources."

Stephen J. Primeau, S.M.'83, is a member of the technical staff of Eagle Research Group, Inc., Arlington, Va., a consulting firm. . . . **Christopher L. Hoxie,** Ph.D.'82, reports, "Currently I am a consulting engineer with NUS Corp., Gaithersburg, Md., and am writing a 3D space-time kinetics computer code for use by the electric utility industry." . . . **William T. McCormick, Jr.,** Ph.D.'69, became chairman and CEO on May 1, 1985, of American Natural Resources Co., Detroit, Mich. Formerly he was president and CEO.

George D. Dooley, S.M.'79, is director of engineering at GRP Consulting, Simsbury, Conn., working on engineering and computer applications for new electric utility industry. . . . **Jules D. Levine,** Ph.D.'63, is now manager of a solar energy program at Texas Instruments, Dallas. . . . After six years with the IAEA in Vienna, **Alan S. Hanson,** Ph.D.'77, has returned to the U.S. to take senior responsibilities at Transnuclear, Inc., White Plains, N.Y.

TECHNOLOGY AND POLICY PROGRAM

Claire Bischoff, S.M.'85, is currently working at the University of Michigan's Institute of Science and Technology, Special Projects Division. . . . **Jean-Bernard Caen,** S.M.'81, has been appointed sales manager for banking in the French subsidiary of COMSHARE, Inc., a U.S. firm. . . . **Stephen Foss,** S.M.'80, is now a patent attorney with the firm of Harness, Dickey and Pierce, Birmingham, Mich.

Dave Rubin, S.M.'83, is a consultant with Pacific Gas and Electric. . . . **Jon Zilber,** S.M.'83, is manager of market research operations for Kessler Marketing Intelligence, Newport, R.I. . . . **Warren Schenler,** S.M.'83, is currently working in the Washington, D.C., office of Energy and Resource Consultants (ERC) of Boulder, Colo.—Gail Hickey, Technology and Policy Program, M.I.T., Room 1-138, Cambridge, MA 02139



From the Mines to the Ballroom

Joe Champagne, '12, who planned to be a mining engineer when he entered M.I.T. but made his career in ballroom dancing, died in Fall River, Mass., on September 17; he was 96.

Champagne ran cotillion dance classes for thousands of Greater Boston children, then taught ballroom dance to officers and their wives at the Naval War College at Newport, R.I. Meanwhile, he and his wife gave dance demonstrations in the Copley Plaza Hotel and aboard famous ocean liners, including the maiden voyage of the *S.S. Normandie*, and he formed and appeared with a popular society dance band, the Billy Lozee-Champagne Orchestra, in the 1930s.

Champagne's career was launched when he took a summer job, while an M.I.T. student, as a dance instructor at a Nantasket Beach hotel. Dancing paid better ($50 a week) than mining ($35 a week), he found out.

Joe Champagne, '12, and his wife, the former Libby Krensky, were well known dance partners, entertainers and instructors for more than 60 years.

PORTRAIT BY STREM

16 70th Reunion

We are pleased with this letter from one of our truly faithful correspondents, **John Fairfield**: "I appreciated the fine tribute to **Shatswell Ober** in the November/December 1985 issue of the *Review*. I knew Ober as well as any of my classmates. He was a good friend of my closest friend, **John Eberhardt**; they both came from within a stone's throw of residences in Arlington, Mass., so we met frequently. We shared many classes. Ober was a naval architect student, inserted with Course IV (mechanical engineering students) because they were too few to make a full section. We three were "brown bagging" commuting students, non-fraternity, students of serious, sober habits. Ober was a fine chap, a good, congenial friend—trustworthy, loyal, quiet, and reserved but genuine. A personal touch: Shatswell and I are very remotely related: our ancestry is tied together five generations back and both lines start with immigration to Salem and Ipswich, Mass. in 1638. My recent activities: gardening, home tending, living alone (with an adorable dog), leaf raking of late (when small boys are unavailable), reading, scrabble, friends as much as possible at our age, and mobility. Same house for 53 years." . . . Sibly Fletcher sends her best wishes to all '16ers. She continues to be very active and is looking forward to being with us for our 70th reunion. . . . By the way, there is a cure for writers cramp—the compelling desire to make others happy by sharing news with classmates.—**Bob O'Brien,** Acting Secretary, H. E. Fletcher Co., Groton Rd., W. Chelmsford, MA 01863

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Edward P. Clayman, writes, "It is with deep regret that I must advise you of the death of my father, **Samuel Clayman,** on September 3, 1984 at the age of 90. He retired 25 years ago from Clinton Co. of Clinton, Iowa, where he was employed as a chemical engineer for approximately 40 years. He is survived by a daughter, Louise C. Krekstein, myself, five grandchildren, and two great-grandchildren."—*ed.* (**Walter J. Beadle,** Secretary, Kendal at Longwood, 217 Dennett Square, PA 19348)

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As of this date I have received no news from any classmates to record in this issue.

Selma and your secretary are now members of a retirement colony owned by Babson College on a hill in Needham, Mass. The Prudential Tower in Boston ten miles away is visible from this location. The village houses 341 families (couples, widows, and widowers) over 62 years of age. The complex is in the form of a wheel with a center core and spokes of apartments. It has a health care center with an adequate staff of nurses. In addition there is a central dining room with all meals available. We moved July 25. Selma required surgery with phlebitis in her leg in September, was in the hospital for a week, then required another week in the health care center before returning to the apartment. We never anticipated that she would test out this facility so soon. She is making a good recovery.—**Max Seltzer,** Secretary, North Hill, Apt. B403, 865 Central Ave., Needham, MA 02192; **Leonard I. Levine,** Assistant Secretary, 519 Washington St., Brookline, MA 02146

19

Perhaps you were disappointed to find no notes for 1919 in the January *Review*. At press time we had no news, and we concluded that no news could at least be partly good news. However, for the following issue once again I didn't have any notes, so I decided to call some classmates and pass on to you what I found. From the comments of those I called, I concluded that our mates are carrying on consistent with their ages and likely glad that they didn't die young.

I started with our class president, **Don Way**. (Aside for a moment, Don has held this office for over 25 years, some sort of record I would say.) Anyhow, I found him at home carrying on while his wife Barbara was away in Japan. In early October Don's wife Barbara made a trip to Japan with their daugther Sharon and her husband, Bill Little. Some class members may remember meeting Sharon and Bill when they were guests at our 65th reunion. Don and Barbara's middle son Christopher, a naval architect, and his wife Patricia, an artist, are living in Japan. The company that Christopher is associated with is under contract at the U.S. Navy base at Yokosuka.

Bill Little was on a business trip, but Sharon and Barbara did a good bit of sight-seeing in the Tokyo, Kyoto, Nara, and Yokosuka areas. While in Tokyo they attended a one-woman print show by Patricia Way at the American Culture Center. Don did not accompany them as he felt the trip was two strenuous.

My next call was to **Tim Shea**. Recently he visited his sister in Newton, Mass. to celebrate her 85th birthday. Tim himself is 87 and comments that he was "one of the younger members of our class." It was a pleasure to have a conversation with him.

My next call was **Oscar de Lima**. He was away in New York so I just left word that a classmate called.

Finally, I called **George Michelson**. His building contract company was located on State Street in Boston for 60 years and recently moved to Newton, Mass. George was out of his office but later called me and said he felt fine and goes to his office daily.

Do write me about you and have a wonderful spring and summer.—**Bill Langille,** Secretary, P.O. Box 144, Gladstone, NJ 07934

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Word has been received of the death of **Ed Cousins,** 1150 West Market St., Akron, Ohio. . . . A phone call with **Frank Maconi** indicates that he remains busy and active in town affairs. He is president of the Leominster Historical Society and is on the investment committee of the Hatch home for retirees. Good for you, Frank.

Another classmate who keeps active is **Perk Bugbee**. He plans to attend the regional meeting of the National Fire Protection Association in Baltimore this fall. . . . A popular and highly esteemed member of the class has made a generous bequest to the Jerome B. Wiesner Freshman Scholarship Fund. **Jim Wolfson** honors the class of 1920 by so doing. To the best of my knowledge, Jim never missed a reunion of the class and was one of our most faithful and steadfast members. We salute you, Jim.—**Harold Bugbee,** Secretary, 702 Country Club Heights, Woburn, MA 01801

21 65th Reunion

Last month I reported the death of **Josh Crosby**. An interesting sidelight has appeared in a letter from Parke Appel, president of the class of 1922. Parke writes that Josh was a freshman roommate of Donald Carpenter, '22, when he was a member of the class of 1921. They both attended Ft. Monroe Officer's School early in the 1918 war. After retirement of some 20 odd years, Josh and Don were both stricken by a stroke and both died on September 28, 1985. Strange coincidences!

In a phone call to reunion chairman **Don Morse,** I learned that an encouraging number of postcards have been received in reply to the class mailing for our 65th reunion this June. The response indicates that a goodly number of classmates hope to attend. It looks like a fine reunion coming up.

Your secretary took a two-week trip to California in October, visiting a brother and three nephews. The visit was to Los Altos and Walnut Creek in the general San Francisco area and included three days in the valley at Yosemite Park. The waterfalls were all beautiful. The walks are steeper than the last time I was in Yosemite, and my old legs ain't what they used to be.

Two deaths are reported this month: **Andrew Deane** of Naples, Fla. on January 30, 1981; and **Herman S. Kaier** of Westwood, Mass. on September 16, 1985. Herman was a native of Norway. After graduation from M.I.T., he worked in the paper industry in Sweden and Norway, then moved to Canada and became manager of the newsprint mills of Abitibi Paper and Power Co. He was active in fund raising, was travel manager of the Norwegian team in the 1932 Olympics at Lake Placid, and was later secretary/manager of the Norwegian-American Chamber of Commerce in New York. In 1943 he was chairman of the Board of Economic Welfare in Washington, handling emergency food shipments to foreign countries. After the war he joined Fearnley and Eger Shipping Lines and became president of the company.

The sympathy of the class is extended to the families of these two classmates.—**Sumner Hayward,** Secretary, Wellspring House E64, Wash. Ave. Ext., Albany, NY 11203; **Samuel E. Lunden,** Assistant Secretary, 1149 S. Broadway, Suite B-800, Los Angles, CA 90015

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The class has lost two more stalwarts, **Donald Fell Carpenter** and **Norman Joy Greene**. Don, while slowly recovering from the stroke suffered in 1984 was fatally striken with pneumonia in August. Don's long and effective record of service to the Institute is detailed on p. A21 of the January *Review*. Norm died November 29 at his home in Newtown, Pa. after a long bout with cancer. A member of Beta Theta Pi, Norm was less well known to most of us, since he left school after his freshman year, but throughout his long and successful life he was an enthusiastic supporter of the Institute. In 1967 he was governor general of the Society of Mayflower Descendents. Norm is survived by his wife Marion and a daughter.

Bill Elmer wrote the Alumni Fund to object to the "atrocious junk art monstrosities" that have appeared on the grounds of M.I.T. in recent years. He asked that his contribution last year be devoted to the removal of these "obscenities," but was told that there is no branch of the Alumni Fund yet established for this purpose. Nevertheless, he says he's going to make the same request again this year and hope that it will be honored this time. Your secretary suspects that many of our generation are in sympathy with Bill's position.

I have recently had brief visits with **Walt Saunders** and **Hall Baker** at their homes in Cape Elizabeth. Both are well. Walt's wife, Ruth, died last summer after a long debilitating illness. . . . **Ab Johnson,** after a summer at his place in Crystal Downs in northern Michigan, is back in Phoenix for the winter. Following the resignation of our treasurer, **Buck Eacker,** and prior to his death, president **Parke Appel** asked **Marjorie Pierce** to serve as treasurer, and she accepted. As of August 31, 1985 the balance for "Class of 1922 MIT" was $4,119.22.—**Yardley Chittick,** Secretary, Box 390. Ossipee, NH 03864

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In late October, **Royal Sterling** had lunch with **Pete Pennypacker** and his new wife and discussed plans for our 65th Reunion. . . . **Ragner D. Naess** writes, "I am having a beautiful time being retired—skiing, sailing, traveling, and going

to my former office once in a while." He claims that Tech helped him a lot in attaining his life accomplishments.

The **Kent T. Healy** Memorial Fund has been established by former students of Kent. He taught transportation at Yale for 42 years, initiating the graduate program in transportation and chairing the Economics Department for seven years. The purpose of the fund is to provide for lectures at Yale, at other universities, at professional organizations, and at other appropriate places to stimulate interest in and knowledge of transportation, with particular reference to railroads. Contributions may be made to K.T.H. Memorial Fund, Inc., 13 South Hill Rd., Jaffrey Center, NH 03454.

Augustus Hermann died last March. He attended courses in civil engineering with our class. His entire career was in the paint industry, in the employ of Samuel Cabot, Inc., of Chelsea, Mass., with various responsibilities as assistant superintendent, superintendent, general manager, purchasing agent, and director. He was president and national director of the International Material Management Society, was on the National Manufacturers Committee of the Federation of Societies for Paint Technology, and was active in the affairs of the National Paint, Varnish and Lacquer Association.

Raymond Meekins died last year. He graduated in metallurgy and materials science. He also studied at the Y.M.C.A. Law School and at a number of Army schools, and he served as a construction management engineer in the U.S. Corps of Engineers until his retirement as a colonel in 1963. He was an elder in the Presbyterian Church.—**Richard H. Frazier**, Secretary/Treasurer, 7 Summit Ave., Winchester, MA 01890

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Mrs. Enid U. Colvin died recently. She was the wife of **Oliver D. Colvin** and is survived by her son, Oliver D. Colvin, Jr., of Cambridge.

Your class President, **Don Moore**, together with **Herb Stewart, Russ Ambach,** and **Dick Shea**, attended the 1985 National Alumni Conference in Cambridge, which featured reports on M.I.T.'s Research Centers. Very interesting talks were given on the status of nuclear power, cancer research, and industrial development. The afternoon session was followed by a president's reception at the president's house.

The above-mentioned four also had a luncheon meeting at which we discussed plans for a letter to all '24 alumni from **Don Moore**, as well as plans for a possible 65th reunion in 1987. All members should be receiving this letter soon.

Your co-secretary **Dick Shea** has just returned from a trip to San Francisco, where he attended the annual meeting of the IEEE Nuclear and Plasma Sciences Society, of which he is editor-in-chief.—Co-Secretaries: **Dick Shea,** 709 Cypress Pl., Sun City Center, FL 33570; **Russ Ambach,** 216 St. Paul St., No. 503, Brookline, MA 02146

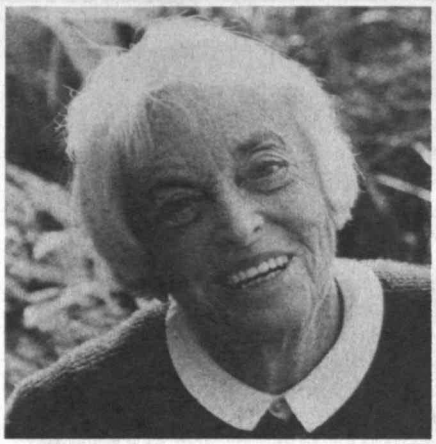
25

The first meeting of the Alumni Council in October found **Jim Howard, Ed McLaughlin,** and your secretary in attendance.

Max King was so kind as to send good news regarding **Finley Laverty**. As the 1985 recipient of the ASCE's Royce J. Tipton Award, Finley received the award at the Society's annual fall convention in Detroit. He has made significant contributions to the advancement of irrigation and drainage engineering through virtually all possible channels of service, including education, research, planning, design, construction, and management.

Ken Lucas writes that he continues active as the president and director of the Massachusetts School of Survey, Inc. It provides continuing education for land surveyors using largely the correspondence method.

Martha Munzer Remembers Oppenheimer



In response to an article on J. Robert Oppenheimer and the radioactive poison plan (May/June, page 14), ***Martha E. Munzer**, '22 right, shares her recollection of an encounter with the great scientist:*

After he had assumed leadership of the Institute for Advanced Studies in Princeton, N.J., J. Robert Oppenheimer spoke with some students from the Ethical Culture School. The students wanted to know how the atomic scientists at Los Alamos felt after the bombs had exploded.

"We at Los Alamos tried to celebrate with a big party but it was a dismal flop," Oppenheimer replied. "I remember dropping in briefly, only to find a usually cool-headed young group leader vomiting in the bushes outside; but it wasn't from too much liquor. And I said to myself, 'The reaction has begun.' "

Oppenheimer went on to explain that immediately after the bombing, Los Alamos scientists began discussing the need to inform American policymakers and the public about the implications of atomic energy. "We felt it our obligation to prepare the way for establishment of international control that would prevent an atomic arms race," he said. "When atomic bombs are added as new weapons to the arsenals of a warring world, humankind will curse the names of Los Alamos and of Hiroshima."

"Are you repudiating science, Dr. Oppenheimer?" asked one of the students.

"By no means," came the prompt reply. "If we yield our belief in the good science can do for the world, we sell our heritage both as scientists and as human beings." He smiled, but what I remember most vividly are his sad and haunted eyes. Behind them seemed to lurk the plaguing question, "What monster have we scientists unleashed?" Later he wrote, "The physicists have known sin, and this is a knowledge that they cannot lose."

It is with sorrow that the passing of two classmates must be reported. **Willard J. Allphin** died in September 1985 at the Hunt Memorial Hospital in Danvers, Mass. Willard was an illuminating engineer at GTE Sylvania for 25 years. He retired in 1957. He received a distinguished service award from the Illuminating Engineers Society. He was active in local affairs and served as chairman of the committee that wrote the Town Manager Act. A former member of the Danvers School Committee and the Danvers Planning Board, he served as town meeting member for several years. Willard leaves his wife, Catherine B. (Washburn); two sons, Kendall of Oakland, Calif. and Richard Allphin of Jamestown, R.I.; a sister, Doralis Cloer of Washington, D.C.; three grandchildren and three great-grand-children.

Edward A. Milne died on June 2, 1985 in San Fernando, Calif. Ed was a chemical engineer with the Kendall Co. and for many years resided in Shelburne Falls, Mass. and had only recently moved to California where he was living with his son Brian.—**F. Leroy (Doc) Foster,** Secretary, 434 Old Comers Rd., P.O. Box 331, North Chatham, MA 02650

26

Bob Sherwood inquired about the reason for the absence of '26 Class Notes in the October issue. Our notes were held over to the November-December issue because of a space problem. The classes selected were from those that had not been held over recently. This is the first time it has happened to us since Smitty's departure, as I have tried to maintain his record. Several other classmates have called on the same subject, indicating the importance to our class of maintaining our 60-odd years of associations.

We have just had our first major Reunion Committee meeting and mailed out the first letter announcing the program, which we believe is well-suited to current conditions and, therefore, likely to produce a high attendance of members, spouses and widows. **Jim Killian**, as our Class President (succeeding **Dave Shepard**), has actively participated in the planning and has been very supportive of the class biography.

John Wills called recently, on the occasion of the passing of one of our classmates, and indicated his intention of making the 60th. . . . In a telephone conversation today with **Don Cunningham** on reunion matters, he mentioned the long-term friendships which have developed through meeting with classmates we had not necessarily known well at M.I.T. Don and Mary have been regular participants in the Quarter Century Club tours; these have resulted in associations with other alumni and several mini-reunions thereafter.

In the past month, regrettably, we have re-

Charles S. "Doc" Draper, '26, Institute Professor, Emeritus, and founder of Draper Lab (far right), visited his hometown of Windsor, Mo. and his cousin, Philip Kilpatrick, who oversees Doc's farm, as the last leg of a very special trip with his secretary, Peggy Hood, last July.

The trip included an awards luncheon, where the American Society of Mechanical Engineers presented Doc with the Spirit of St. Louis award, a visit with Stanford University professor Holt Ashley, attendance of the Aviation Hall of Fame's enshrinement ceremonies to honor Apollo astronaut Mike Collins, and another look at the plaque which commemorates Doc's enshrinement in the Hall of Fame in 1981.

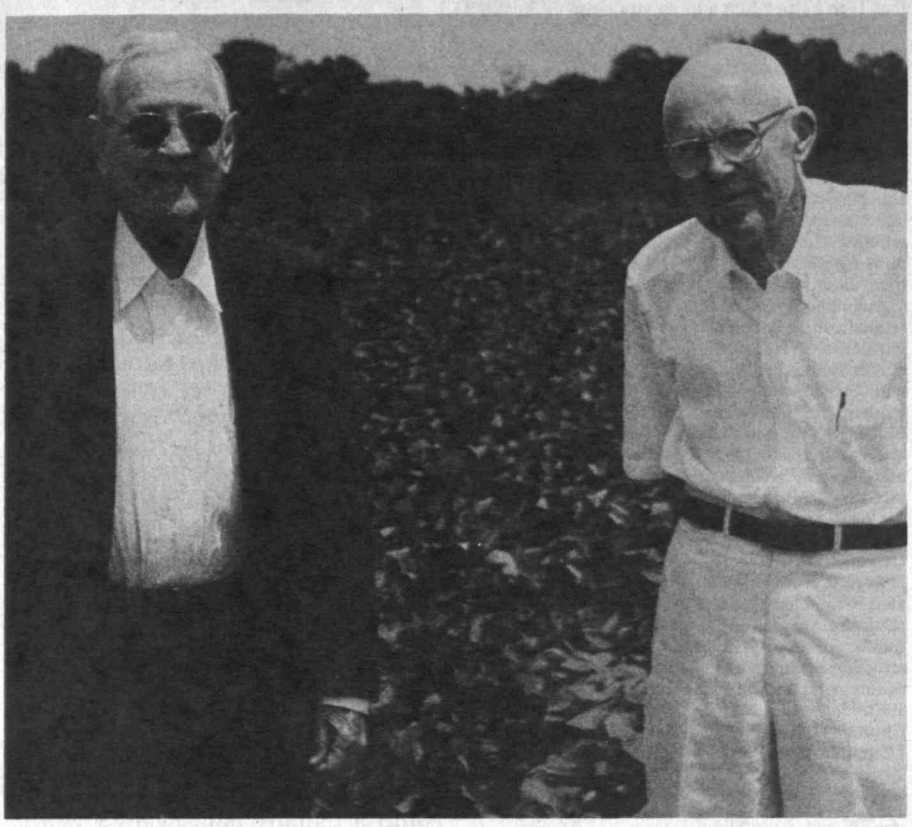


PHOTO: *D-NOTES*

ceived from the Alumni Association notices of the deaths of three members of our class for whom we have no data except addresses. It would be appreciated if any of you who have further information could let us know. Deceased: **Joseph Y. Houghton**, 3616 Legation St., Chevy Chase, MD 20015. No date. . . . **William B. Millar**, Box 645, Patagonia, AZ 85624. Date of death: August 29, 1985. . . . **Francis A. J. Brown**, 824 Lehigh Ave., Lancaster, PA 17602. Date of death: April 17, 1985.—**William Meehan**, Secretary, 191 Dorset Rd., Waban, MA 02168

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F. Sidney Badger, Jr., lost his wife Lenore in 1983, after 48 years together, and now keeps bachelor quarters with his son Frank S. III in Woodland Hills, Calif. He has been a mechanical and chemical engineer consultant for Beckman Instruments since 1966; now and then he receives a request for a report on troubles with production at the company and other matters. He recently attended a wine-tasting luncheon of the Independent Metallurgical Consultants of California. Sid plays golf often and can break 100 if he leaves out one hole. . . . **Samuel A. Kaswell**, in Tamarac, Fla., is taking good care of his health. He plays golf occasionally, swims, and rides his bike daily. He helps with the activities of the Ft. Lauderdale Alumni Club and is looking forward to attending our 60th Reunion. . . . **Richard L. Cheney**, in Santa Barbara, is feeling okay. Dick has resigned from several of his responsibilities now but still manages their condo complex. He and his wife, Estelle, recently returned from two months in an apartment near Villars, Switzerland, in the ski area—they enjoy this annually. They are hoping for a trip to Montreal, Quebec, and New England next fall. Your Secretary is impressed with the latest idea from "Hour Magazine" on TV for fellows of our vintage—the "no-diet diet." Eat what you like but less and don't let your mood change your plan.—**Joseph C. Burley**, Secretary, R.F.D. #3, Epping, NH 03042; **Lawrence B. Grew**, Assistant Secretary, 21 Yowago Ave., Branford, CT 06045; **Prentiss I. Cole**, Assistant Secretary, 2150 Webster St., Palo Alto, CA 94301

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The Alumni Office promotes several telethon sessions each fund year and we, the local alumni and alumnae, are invited to participate. On the appointed date for our class, October 21, **Jim Donovan** with Florence and **Walter Smith** spent the evening making telephone calls to those of our classmates that could be reached at the time. We thank all of you for consistently warm and gracious responses. Alumni financial support to the Institute is critically important and most of us fully recognize how much we owe M.I.T.

The many calls had to be brief, of course, but a few messages did come through. **Gil Toone** took the occasion to do a short bit of reminiscing and recalled how, as a freshman, his locker was near those of **Gus Solomons** and your secretary. This is how many acquaintances began. . . . Our call to Gus himself gave us the news that his son, Noel (M.D., Harvard) has gone to take up teaching in Central America. . . . **Frank Webster**, though retired, is still active with his son in their own business. . . . **Al Dempewolff** writes a weekly business column for his local newspaper. . . . **Tom Harvey** and wife Gracia, having had several Mississippi River cruises, now plan on taking an M.I.T. related Rhine River cruise.

Hal Dick expressed an interest in the upcoming '28 60th reunion. . . . **Herb Dayton** sent his regards from Texas and spoke of some of the hurricanes he has experienced. . . . **Dave Ingle** has several church-oriented interests. . . . **René Simard** says that he and Pam spend about four months of each year at their summer home on McGregor Lake in the Province of Quebec (about 25 miles from their year-round home). . . . **Slim Maeser**, despite some health problems, is still doing okay. . . . From **Maury Beren** we learned that **Sid Brown**, whose wife, Sydney, died a few years ago, has now remarried. (To you, Sid, and your bride, our very best wishes.)

Art Josephs, recipient of the 1985 George B. Morgan Award, wrote to **Jim Donovan:** "I am busy on a number of civic projects and spending a good deal of time reading and wondering, now that I have reached the age of wisdom, what the hell it's all about. I was told years ago, by a friend of my father's, that it takes courage to grow old. I suppose the trick is to do it gracefully. My best to you, to yours and the gang. I will try to make it to the 60th."

We hear that Marie, **George Chatfield**'s wife, is receiving piano lessons from her daughter, Susan. This may seem a bit strange when one considers that Susan, a voice and piano teacher, lives in California while the Chatfields are in New Hampshire, several thousand miles away. The feat is accomplished by the use of VCRs and the U.S. Mail.

With deep regret we must record the death of our classmate, **Carl M. Loeb, Jr.**, on August 13, 1985. As a member of our class, Carl received his S.M. degree in Course III, materials science (metallurgy). His professional career was in metallurgy both as an enginer and as an administrator. He was with Anaconda Co. initially for a few years, then went to Climax Molydenum Co. (now a part of AMAX, Inc.), where he became vice-president for development. His interest and activity in social service work was in the field of crime and delinquency control. His many other interests are reflected in the broad range of civic, social, and technical groups to which he belonged. Included here was his continued and loyal support

of M.I.T. To Carl's family we extend our heartfelt sympathy.—**Walter J. Smith,** Secretary, 37 Dix St., Winchester, MA 01890

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Amasa G. Smith of Birmingham, Ala. has been one of our most faithful contributors to class notes during the past 16 years since I have been secretary, for which I express my appreciation. Amasa writes, "I have been working all year as chairman of the building committee of a private club here, 'The Club,' located on top of Red Mountain above the city. We are just completing an $8 million ballroom, which is outstanding. Hope you will come here sometime so we can show you this and other interesting things in our fair city.

"**Larry Luey** is still doing fine and plays golf with us now and then. I lucked out on a good score today, '84, a little above my age, '79. We do so enjoy your class notes in the *Review*. I seemed to have lost most of my friends from the school, either by death, or, like me, they've become too lazy to write. Look forward to seeing you one of these days. Best regards to all." Amasa has always been active in community and civic affairs. He puts most of his energy into Community Chest (United Appeal), Boy Scouts, YMCA, Food Bank, and others.

Rolf Zurwell of Forest Hill, Md. sends a brief note: "Zurwell Co. continues in business, product design and engineering consulting. At age 79, I am blessed by the Almighty God in Christ to be in good mental and physical health. M.I.T. must never be ruled by a few dissidents concerning research on the space defense system. It is not immoral for a nation to develop systems against nuclear attack from any source." . . . **Donald S. Hersey** of East Hartford, Conn. writes, "Health problems early in 1985 have limited my physical activities somewhat. But, with the help of my good wife, I manage and participate in shopping and household activities." His hobbies including painting (art), gardening, piano, reading, and crossword puzzles.

Eric A. Bianchi of Tequesta, Fla. lost his wife Kay a few years ago. Those of you who have had the same experience realize that losing a lifelong partner is devastating, and the loneliness that follows is even worse. Eric sends good news: "I am happily remarried as of October 1984 to a lovely lady who was almost a neighbor. We continue to live in the same community and enjoy life together. Helen was a widow for five years after losing her husband, a member of the Dartmouth College class of 1929. We are both active in the affairs of Tequesta Country Club, Helen in bridge and golf and club management for me, currently as president. We recently completed a seven-week trip to Horth which included my annual visit to the Bald Peak Colony. Tried to reach Joan Gale, but learned she was visiting her brother Tim in Kenya. Subsequently we were chased off Cape Cod by hurricane Gloria."

Bill Baumrucker of Marblehead, Mass. still plays tennis twice a week, but says the old legs don't seem to stand up as in the past. He sends his regards to all. . . . **Thomas W. McCue** of Newton Highlands, Mass. is still continuing his adult education in economics, real estate sales, and financing at Suffolk University. He still does some part-time sales promotion and spends a great deal of time for the M.I.T. Alumnni Fund, participating in the telethons, telephone solicitation to alumni. He received a citation last year for devoting many hours of work for so many years. . . . **John Russell Clark** of Dallas, our current president writes: "Just returned from our annual trek to Colorado mountains in October—as usual, snowcapped mountains and aspens in full fall colors plus some snow in the passes. Our condominium in Steamboat Springs, Colo. is 965 miles from Dallas. I don't seem to find enough time to read all that I feel I should. Good luck and best of health to all of the classmates."

I regret to announce the deaths of the following members of our class: **Daniel Silverman** of Tulsa, Okla. on June 2, 1985; **Michael C. Casserly** of Burlingame, Calif. on September 8, 1985; **Phil W. Sayles** of Lakeville, Conn. on September 23, 1985; and **Henry L. Giles,** Pasadena, Calif. on October 21, 1985.

Michael Casserly was a member of a pioneer California family and the grandson of Eugene Casserly, an attorney who settled in San Francisco in 1850 and later became a U.S. senator. Michael was born a month before the San Francisco earthquake and fire, and the family fled to San Mateo county with only a horse for transportation. He was a test pilot for United Airlines. . . . **Phil Sayles'** daughter wrote to say her dad passed away. He had recently moved to her home in Washington, D.C. because of ill health. She writes, "My mother also died a short time after my father, so it has not been a very good fall. Dad graduated from the University of Illinois in 1927. While an undergraduate, he had his own orchestra and played the piano. He entered M.I.T. as a graduate student and took up electrical engineering. He worked mostly for General Electric for a total of 44 years, first in Lynn, Mass., then in Schenectady, N.Y., and finished his career in New York as a marketing and personnel consultant. He moved to Lakeville, Conn. and became an excellent golfer. He left two daughters and three grand-children. . . . Thomas D. Green, '26, sent a memo and newspaper clipping announcing the death of **Henry L. Giles.** Mr. Green states that Henry was a good friend of his and a neighbor. We got acquainted in the early thirties as members of the (then) Technology Club of Hartford, Conn. After Henry received his S.B. in civil engineering, he went to Hartford and took a position in the state health department, specializing in the water supply and sanitary waste disposal. He later became city engineer for Meriden and the city of Hartford. During his 30 years in West Hartford, he was active in the Boy Scouts, was a member of the Society of Professional Engineers, and was a member of the Hartford model yacht club. In 1962, he moved to Pasadena, Calif. and served as city engineer for 17 years. He is survived by his wife, Myrtle (Glass), a son, a daughter, six grandchildren, and one great-grandchild.—**Karnig S. Dinjian,** Secretary, 7161 Promenade Dr., Apt. 502, Boca Raton, FL 33433

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Reports by **Charley Abbott** from Sarasota, Fla., **Ralph Appleton** from Columbus, Ohio, **George Barker** from McHenry, Ill., and **Ronald Youngson** from Oshkosh, Wisc., indicate that all four are retired and are enjoying sufficient health and mobility to engage in such activities as hunting, fishing, gardening, woodworking, and travel. . . . As previously reported, **Frank Hankins** took early retirement because of Parkinsonism, which now appears to be stabilized. After several years of shuttling between Franklin Lakes, N.J., and Fort Pierce, Fla., Frank and his wife elected to make Fort Pierce their year-round residence. They have a house on an inland waterway with an O'Day sailboat anchored "in their front yard." The Hankins have three children: Tim, a professor at Dartmouth; Frank, a captain with Republic Airlines; and Anne Bing, who has four children, and runs in the Boston and New York marathons. . . . We have a notice that **Emilio (Maco) MacKinney** died in Mexico City on February 25, 1985. Unfortunately, I have very little information about him in my files. He and his wife, Doris, came to a number of reunions over the years. Those who went to the 45th Reunion at Chatham Bars Inn may remember that the McKinneys attended with one of their children. Maco's death was reported by a son, Ricardo MacKinney Stephenson.—**Gordon K. Lister,** Secretary, 294-B Heritage Village, Southbury, CT 06488



At a Council for the Arts dinner early last October where Harold E. "Doc" Edgerton, '27, Institute Professor, Emeritus, received the 1985 McDermott Award, he showed slides from his collection. In the above slide, a French boy stands against a background of 300 B.C. amphorae (wine jugs) recovered from a sunken Greek ship during a 1954 Jacques Cousteau archeological expedition.

"His discoveries in the fields of stroboscopy and high-speed photography have changed the way we perceive nature and our relation to it. His flair in the classroom has made that work thrilling to generations of students," reads Doc's award citation.

Long recognized for his scientific contributions to society, the award honors his work as an artist. "With Doc, the selection of subject is infallible, the composition inspired, and the moment of visual impact uncanny," says Jim Plaut, council member. He adds, "There is simply no one like him in the whole world. I consider him a superb artist, and I love him for his art."

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On October 21 **John Brown** and I participated in the Alumni Fund telethon. **Al O'Neil**, who is usually with us, had a minor but painful injury to his finger and could not attend. Many of the notes for this issue were obtained by talking to our classmates while raising money for the Alumni Fund.

Professor **Elmer H. Stotz**, although retired, is busy with many activities at the University of Rochester Medical School. He and his wife Doris travel, recently spending three weeks in Ireland, as well as some time in Boston and Bermuda. . . . **W. Stewart Roberts** is still active in engine investigation, but thinks he is approaching retirement. He recently had heart surgery—recovered well and now feels fine.

James Ritchey is a volunteer at the Presbyterian Seminary Hospital. He feels well, but his wife Esther is arthritic. Although he has lost touch with most of his classmates, he hopes to come to our 55th. . . . **Harry Johnson** is still busy with the educational aspects of the Columbus Association of Purchasing Management. He is active in the M.I.T. Club of Central Ohio, which recently had open house for prospective M.I.T. students. . . . **Dana Price** is working as a consulting engineer for his company. He is active in many organizations, including the M.I.T. Club of Texas. He runs three miles a day.

Robert Prescott is retired. He and his wife Louise have moved to a smaller home in Scottsdale, Ariz. They had to dispose of a good deal of New England antiques. They enjoy two wonderful grandchildren. . . . **Carl Wahlstrom** leads a quiet life. His is amazed at our ever increasing expenses and wonders how long it can keep going up. . . . **Thomas R. Smith,** is still active in his company. They make fractional horsepower drive belts out of polyurethane. He and he wife Charlotte do some traveling. Their most recent trip took them to Holland, France, and Switzerland. Their two grandchildren keep them busy.

Carl Bunker, Jr., of Buffalo, N.Y., spends his summers in East Falmouth, Cape Cod, Mass. His voice sounded strong to me and he was in good spirits. . . . I discussed the 55th reunion with all the above classmates. It was interesting that all were hoping to come, even though in some cases they wonder who they will know when they come. I assured them that they will know practically everyone when they leave.

We have received the sad news that **John E. Meade,** 75, died recently after suffering a heart attack. He was a Raytheon radar engineer, where he worked for 20 years before retiring in 1975. His early work was with the M.I.T. radiation laboratory and naval research in Washington. He made many valuable contributions to the development of radar. He leaves his wife Margaret, two daughters, and three grandchildren.

We also received word that **Rolf Wallin** died on April 10, 1985 of a heart attack. We'll pass on his obituary when we receive it.—**Melvin Castleman,** Secretary, 163 Beach Bluff Ave., Swampscott, MA 01907

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Robert Hegie writes that he is again budget and finance chairman of the town of South Palm Beach. At the same time he is president of their cooperative and is fairly active in consulting. . . . Delphin and **John Sterner** spent last summer at their place, Queechee Lake, Vt. En route back to Miami they stopped at Keene, N.H., and had lunch with the **Stanley Walterses**. Stan says he saw **Ed Simpson** on TV last summer, on a small boat from Logan airport to the South Shore. . . . **Dick Morse** reports that they didn't get in their summer cruise to Maine but did have a five-day cruise to Badeek in northern Cape Breton; it was nonstop from Quissett on Cape Cod, and they saw whales, porpoises and fog.

A memorial service was held in Malden for **Jim Turner**, who was a vice-president with Textron and Talon. He was always active in class affairs and will be greatly missed. . . . **Fred Kressman**, our pine products classmate in Florida, died in August. . . . **Horace K. MacKechnie** writes that they have a daughter starting to teach advanced nursing in Morgantown, W. Va. They will be moving to a new retirement home in August. . . . **George Stoll** reports that Huricane Gloria left them without water or power for a few days, but neighbors came to the rescue. The Stolls were good Samaritans to some of their friends too. . . . Fay and **Alan Hinkle** stopped to see the **Mal Mayers** when the leaves were pretty and enjoyed a picnic lunch. They, too, lost their power when Gloria passed by.

Charolee and **Dick Fossett** made their annual hiking trip in the Alps, and then returned to New Egland to see one of their grandsons become an Eagle Scout. Dick says **Steve Rhodes** is still very active in his company, M.M. Rhodes, making staples and small fasteners. Steve and Esther visited the Fossetts in California last year. . . . President **Morse** sends word that those living in Florida can write the alumni office to get notices of M.I.T. activities in the Palm Beach area. He and **Cy Hapgood** will be there this winter.—**Beaumert Whitton**, Secretary, Cottage 112, Sharon Towers, 5150 Sharon Rd., Charlotte, NC 28210

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Some time ago, **John Taplin** asked me to print this message: "I want to thank all of our Gift Committee members and all our contributing class members for making it possible for our class to establish the highest participation percentage of 96% and the second highest gift level of $3,740,000." It has been reported that subsequently we reached an impossible 97.5% and a gift over $4 million.

Here's a letter from **Earle Megathlin** that got lost in my highly "organized" files for two months: "Will try briefly to bring you up to date. Our children are all doing fine, Barclay is on the editorial staff of IBM in Raleigh, N.C. Earle Jr. is an engineer with Pratt and Whitney in Palm Beach, Fla. Ginny is living in Greensboro, N.C.; her husband runs the Force Measurement Division of John Chattilion and Sons. And we have a total of eight delightul grandkids, whom we see often. Aimee and I are in good health and we are enjoying life immensely. A few years ago we bought an automated full service car wash here in Ocala. It has been great fun. I work as much or as little as I want and have something to tinker with. And I enjoy working with the young people I employ rather than the bellyachers of our generation. I recently decided to try something new, so I wrote and published a book about prayer, "Whey Doesn't God Do What We Tell Him?" This was quite an experience. I found, among other things, that an unknown author, with no credentials, using a subsidy publisher, who says something which might interfere with the prevalent exploitation of prayer for aggrandizement, has a slim chance of breaking into the literary world with a crash. Oh well, it's a good book and should be required reading for any of our classmates who still harbor the concept that we live in a world of natural causes in a closed system. If anyone's curiosity consumes him, the publisher is Dorrance and Co. in Bryn Mahr, Pa."

This note comes from **Les Brooks** of Rockmart, Ga.: "Our daughter and some of the grandchildren from Boise, Idaho, visited us for 12 days in August and left us close to being basket cases. We toured Atlanta, attended a rodeo, golfed, went swimming, drove up in the mountains to see the Alpine Village (Helen, Ga.) on a visit to the Georgia State Fair at Hiawassee, the gold museum, at Dahlonega, etc., etc. Worse than exhaustion was being chagrined by a 12-year-old grandson with his short sticks whacking out the ball over 200 yards and getting consecutive holes the several times we played." . . . **Ed Taubman** writes from Towson, Md., "After four months of procrastination, I finally consolidated the video pictures of our 50th Reunion on one VHS cassette. I am donating two copies to the class. The first 10 minutes are of the 45th Reunion in 1980 and the next hour is the 50th. While the finished result is not professional (after all, I am an amateur), the faces and voices are very recognizable. Occasionally when the light was poor, it's a little fuzzy, but all in all I'm proud of myself. Of course, having a camera made for idiots helps a great deal. If classmates want a permanent copy for themselves, they can write me direct (828 Dulaney Valley Rd., Towson, MD 21204) and I can have it made locally for $15.00, which covers cost of blank cassette, cassette case, recording, and postage. This is a VHS cassette and *not* a Beta, although I understand a Beta can be made from my VHS." Let me hear from you if you want the loan of a VHS cassette to view and possibly make your own copy. In the meantime I shall be in touch with **Bernie Nelson** to see if we can set up a screening of the tape at M.I.T.—**Allan Q. Mowatt**, Secretary, P.O. Box 524, Waltham, MA 02254

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By the time you read this, I trust that you will have long since received the 50th reunion mailing with information about the program, registration, transportation, etc. If you haven't, please communicate with me at once! I look forward to greeting each and every one of you in McCormick Hall on Wednesday, June 4. I feel that the committee has planned a good program for the two days at M.I.T. and the two days at the Chatham Bars Inn. If you haven't already registered, there is still time.

I regret to report the deaths of two more classmates. **Richard F. Harvey** died in New Canaan, Conn. in January 1985. He was retired as a research metallurgist in the steel industry, having worked in Braeburn and Pittsburgh, Pa., and in Michigan. I have no further information. . . . **W. Vernon Osgood,** who was retired from the Plastics Division of Du Pont in Orange, Tex., where he was a staff engineer, died in March 1985. Although he retired in 1978 he continued consulting with Du Pont and since our last reunion had moved to Kaneohe, HI. He was an avid orchid grower and gardener. At the time of our 45th, he reported four grandchildren and two sons. I have no other information.

In closing let me once again urge you to come to the reunion, if you have not already made that decision. We have a great many years of news and happenings to catch up on.—**Alice H. Kimball,** Secretary, P.O. Box 31, West Hartland, CT 06091

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Correction: The editor apologizes to Mrs. **Robert Lee Alder** for the misspelling of her late husband's name in the class of '37 column for November/December. A scholarship fund for junior and senior engineering students at the Institute has now been established in Mr. Alder's name. Anyone wishing to contribute to this fund should send their contributions to the "Robert Lee Alder (1937) Engineering Scholarship Fund," Office of the Treasurer, Room 4-104, M.I.T., Cambridge, MA 02139.

Phil Bliss retired in 1981 from P and W Aircraft and is now working as a consultant for a commission on aging. He is a fellow of A.S.T.M. and of I.S.A., and a life member of IEEE. He has published several I.S.A. papers, is a member of the I.S.A. and A.S.T.M. Standards Committees, and a contributor to two A.S.T.M. Special Technical Publications. His activities and hobbies are church, amateur radio, computing and music. His travels have taken him to England, Hawaii, Yuca-

tan, Bermuda and much of the U.S. His wife's main interests are gardening and swimming. He has four children and three grand-children; son Jonathan is a graduate student at M.I.T. . . . **Charles C. Chase** retired in 1982 as a financial analyst with Capital Formation Counsellors. Charles received a citation from the second Hoover Commission and the Distinguished Service Award from the Society for Systems Management. He has published a number of articles for the *Journal of Systems Management and the Office*. His hobby is music. His wife Dorothy's main interests are him, backgammon and bridge, but "not necessarily in that order." He has been more or less inactive since a heart attack in 1984.

On September 18, **Carl G. Sontheimer**, president of Cuisinarts, spoke at a dinner meeting of the M.I.T. Club of Fairfield County, Conn., on "Trials and Tribulations of Starting Up Companies." Carl started Anzac Electronics and C.G.S. Laboratories prior to Cuisinarts, so he is well-qualified to discuss the subject. . . . At our 25th Reunion, **William P. Bakarian** was president, general manager, and director of R-N Corp., a subsidiary of Republic Steel Corp. and the National Lead Co. He left in 1965 to form his own consulting firm, P. William Bakarian and Associates, Inc. His worldwide consulting has included three missions to the Ministers of Economy, Industry and Minerals, Petroleum, and Finance in Iraq and Quatar. Bill writes that he plans never to retire and will continue to work whenever he can drum up a project. He travels all the time, mostly on work, but has never been to the People's Republic of China, so he's looking for a project to take him there. He holds the Air Force Legion of Merit and the A.I.M.E. Research Award, and was designated for the "Cedars of Lebanon" medal for contributions to the Middle East. He writes that his wife's main interest is "bossing me around—love it." He has two daughters, two granddaughters, and two grandsons.

I just learned that **Phil Scarito**, whose death I reported two issues ago, was survived by his wife, whose address is R.D. 2, Box 136, Douglasville, PA 19518.—**Lester M. Klashman**, Assistant Secretary, 289 Elm St., Apt. 71, Medford, MA 02155; **Robert Thorson**, Secretary, 506 Riverside Ave., Medford, MA 02155

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Frank Atwater recently completed a four-week consulting assignment with the Port Said Co. for investment and development in Port Said, Egypt, as a volunteer with the International Executive Corps. Frank is presently living in Clover, S.C.

Cliff Nelson writes that he is still working mornings on ECG research at the Maine Medical Center. Last year he had a paper on "A two-dipole model of the heart" at the International Biomedical Engineering Congress in Helsinki.

Nick Barbarossa retired in 1977, but writes that since then he has worked for the U.S. State Department Aid Program in North Yemen, for Harza Engineering in Pakistan, and others. While he still does some work as a water resources consultant, considering his 11 grandchildren, he has eliminated work overseas.

Frank Gardner presently lives at Eastham in Grantham, N.H., on a lake where he canoes and sails in the summer, and cross-country skis or snowshoes in winter. He is active in the local Environmental Protection Committee.

Dave Wadleigh, who is chairman of the 50th reunion committee, has asked me to remind you to save June 1-5 for 1938 in 1988. Dave has a very ambitious and provocative program in store for us.

Ed Hadley, in charge of the 50-year class gift, tells me that he presently has commitments for over 40 percent of our $4,300,000 goal. Remember, each gift during the five-year period before June 1988 will help us exceed our goal.

And, to help you get in the mood for 1988, class president **Don Severance** reminds you that we have a mini-reunion dinner coming up at the Endicott House Friday, June 6, 1986. For further details, drop a line to Don at M.I.T., Room 10-283.

Finally, on a sad note, Morris Nicholson, '39, wrote to tell me that **Ari Gould** passed way last June. Art had just retired from Lehigh University, where he was the Alcoa professor of industrial engineering.—**A. L. Bruneau, Jr.**, Secretary, 663 Riverview Dr., Chatham, MA 02633

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Harold Muckley was honored by election to life membership on the M.I.T. Corporation. Hal's career includes six years in the steel industry and 21 years in contracting and pipeline construction. He served as chief executive officer of Houston Contracting Corp., as consultant to several federal administrations, and as president of the Pipeline Contractors Association. Before his recent election, Hal served two five-year terms on the board of the M.I.T. Corporation. Over the years, Hal and Mary Elizabeth have visited **Mike Herasimchuk**, **Hal Chestnut**, **Shorty Merriman**, and **Irv Peskoe**. These days, and from their Houston home, they enjoy family activities with four children and nine grandchildren.

Clint Lawry reports that his five grandsons and six granddaughters graciously gave him time to relay, from Schenectady, a press report that **Hal Chestnut** received the 1985 Bellman Control Heritage Award in recognition of his distinguished lifetime career of contributions in the field of automatic control.

Nancy and **John Alexander** are remodeling their home in Bellevue, Wash., and they treated Hilda and me to a stirring band concert performed by the great U.S. Marine Band in the Seattle Opera Center. John and Nancy act as general contractor for the comprehensive remodeling, as John continues with his ham radio hobby and design of a new antenna, and Nancy becomes ever more ready to welcome a prompt finish to the construction activities. It seems there is a different feeling within close quarters on a 48-foot sailing vessel during a 22,000-mile transpacific round trip and similarly during an onshore house remodeling as craftsmen do their hammering and plumbing. . . . Mary and **Jim Barton** travelled to New Hampshire to attend a reunion of classmates with whom Jim graduated from high school 50 years ago. They visited **Gordon Pope**, who by then had made good recovery from a stroke which occurred during a recent visit of Lucile and **Bill Brewster** to the Pope estate in Puerto Rico. Jim reports that **John Herlihey**, who flew B-17s during World War II, attended the 40-year B-17 anniversary celebrations at Dayton. . . . Billie and **George Cremer** toured south and central California in their luxurious motor home. After reminiscing with Los Alamos friends at Livermore they visited **Ben Badenoch**, who has been winning championship trophies in glider contests.

Joe Mazur reports that **Charles Friedman** died November 19, 1985. There are no further details at this time.—**Hal Seykota**, Secretary, 1415 Seacliff Dr., N.W., Gig Harbor, WA 98335

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Had an opportunity to visit with Cynthia and **Ty Marcy** at their charming house in Brewster, Mass. (Cape Cod). Although retired, Ty has set up an electronic laboratory where he and two associates are actively engaged in developing new digital computer products.

Our class treasurer, **Ed Bernard**, mailed out invoices for the 1985-86 dues in mid-September. Through October 31, 157 members (35 percent) have responded. He looks forward to hearing from the rest of you in the near future. Ed indicates that final agreements with M.I.T. have not yet been accomplished so that a financial report on the 45th reunion can be provided . . . hopes to do so in the next two or three months.

Ed has noted at reunions that often class members living in the same area do not know or maintain contact with each other. If any classmates are interested in meeting other classmates living in the same area, Ed will furnish lists grouped by zip code. Write to Ed requesting zip code or codes you want covered. You must specify in your request that it is for social purposes only.

A note from **John Kapinos** in Chicopee, Mass. indicates he is retired and in great shape physically. He restored a small house during the past year. One daugther in San Francisco and one on Long Island, both doing well.

William G. Peck writes that he is retired from Communications Satellite Corp. (Comstat). Spent last summer playing Hammond organ for musical activities at Camp Winnebago, Fayette, Maine. Living in Silver Spring, Md., Bill has been involved with various musical organizations in the Washington, D.C. area including the University of Maryland chorus.

I received the sad news that **Richard O. Spalding** passed away on Wednesday, September 11. His widow, Mary Ellen Spalding's address is 810 Lake Dr., R.R. 3, Fremont, IN 46737.—**Donald R. Erb**, Secretary, 10 Sherbrooke Dr., Dover, MA 02030; (617)785-0540

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Plans for the 45th Reunion are coming along. If you have not heard from **John F. Sexton** and **David W. Howard**, co-chairmen, write to M.I.T. class of 1941, 77 Mass. Ave., 10-115M, Cambridge, MA 02139. . . . **Richard Herman Gould** is alive and well in Newton Center, Mass., and is working at Anderson Power Products. Startling news, because our October issue reported his demise. (Richard Hartshorn Gould, Jr., died in 1982). . . . **Edward F. Brady** of Seattle is still working. He has three grandchildren. He will not come to the Reunion. . . . **William C. Brown** of Weston, Mass., is a consultant and is also unable to attend. . . . **James H. Cheek, Jr.**, of Nashville, Tenn., is also still at work. Jim has three grandchildren and hopes to attend the 45th.

Raymond G. O'Connell, former president of the Torrington Co., was appointed to the Litchfield, Conn. Board of Wardens and Burgesses. Ray has also served as president of the Chamber of Commerce, director of the Connecticut Public Expenditure Board, and for 12 years, on the Board of Education of Litchfield. His classmates will remember Ray as a star of the Dramashop during student days. . . . **Frank S. Wyle**, chairman of Wyle Laboratory, El Segundo, has served on the M.I.T. Corporation board since 1982 and has just been re-elected to another two-year term. In the November issue of *Business Week*, Frank and Edith's son, F. Steven Wyle, appears in the "Movers and Shakers" column as a full-fledged entrepreneur. Steve is the co-founder and vice-chairman of Lisp Machine, Inc.

Joseph Lester Klein died of cancer August 3, 1985. At M.I.T., he studied Metallurgy, X-ray and nuclear physics. He helped to design propeller blades for the Navy. He later was with Crucible Steel in Harrison, N.J.; research director of Jessop Steel; a member of the metallurgical projects team at M.I.T. in 1948; vice-president of Nuclear Metals in Concord, Mass., from 1954 to 1968; branch manager of physical metallurgy at Texas Instrument in Attleboro; and director of research and later vice-president of engineering and development at Bird-Johnson. . . . Mary-Olive H. Flowers of Finlay, Ohio, writes us that her husband, Dr. **Fred F. Flowers**, died June 29, 1985. . . . **George R. Bises** died October 23, 1984. George retired in 1983 from Westinghouse Electric Spa., Milano, Italy. He made his home in Geneva and Crans, Switzerland.

Chester N. Hasert of Falls Church, Va., sends a clipping about **Charles S. Butt, Jr.**, his former roomate. Neil H. Greenberger, special correspon-

dant of *The Washington Post*, calls Charlie "The American Legend of High School Rowing Coaches." His crews won 11 National Championship Titles and two victories at the Henley Regatta in his 36 years of coaching crews at Washington-Lee; in one day at Stotesbury, Pa., his crews took home championships in five different classes. Charlie admits he may have sacrificed time with his wife Millie and their five children. Chester remembers some other crew members in our class: **Joe Gavin, Carl Mueller,** and **Herman Affel**. Chet was visited recently by **Quentin Wald**, who has retired from Electric Boat and is planning an extended sailing cruise in the Mediterranean. He also has heard from **Conrad Nelson**, who has retired and lives in Minneapolis. . . . **Robert Wilson Blake, Jr.**, sent the same clipping about our now-famous Charlie. Bob is looking forward to our 45th. He has been in touch with Dr. **Albert H. Bowker**, head of the School of Public Management at the University of Maryland, and with **Walter P. Keith, Jr.**, who is still active in his company but also spends time at St. Petersberg. Bob enjoys visiting **Joseph S. Bowman** and his wife, Ginny, during the skiing season, "passing through." Joe is president of the Fluor Oil and Gas Co., a worldwide oil and gas exploration company and a producing subsidiary of the Fluor Corp., Irvine, Calif. He has six grandchildren: four girls and two boys. He and his wife, Virginia, will come to our 45th Reunion. What would Joe do differently in his life? He would select wealthy relatives (particularly parents) and take vacations instead of postponing them. He has little time for constructive hobbies—too many trips to London, Athens, and Buenos Aires. Bob Blake has retired and divides his time between sailing and skiing. He suggests the reunions committee give to those that come to the Reunion a high-quality light-weight red windbreaker with an M.I.T. Class of 1941 logo and seal.—**Joseph E. Dietzgen**, Box 790, Cotuit, MA

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The news this month is sparse. I am grateful for the lack of obituaries, but more glad tidings would be welcome.

The *Wall Street Journal* reports the resignation of **Jim Spitz** as president and director of International Flavors and Fragrances, Inc., New York City. Jim will continue as a consultant to the firm.

The major item is the announcement by M.I.T. Provost John Deutch that the first appointment has been made to the Class of 1943 Career Development Professorship. Professor Sylvia T. Ceyer has been named the first holder of the chair for a three-year term.

Professor Ceyer received a B.A. in chemistry from Hope College, Holland, Mich. (1974), and a Ph.D. from the University of California, Berkeley (1979). She has been assistant professor of chemistry at the Institute since 1981. In the words of Professor Deutch, "Professor Ceyer was selected to hold this chair because of her outstanding contributions to both education and scholarship in physical chemistry. In particular her recent work on chemisorption processes has been described as a stunning piece of work and a result of such elegance and importance that it will be a classic 'textbook' example."

Our class can take great pride in the establishments of this professorship and in having its first award go to such an outstanding young teacher and researcher.

Perhaps there will be more news with the spring thaw.—**Bob Rorschach**, Secretary, 2544 S. Norfolk, Tulsa, OK 74114

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The Mini-Reunion at Williamsburg last November—months ago, but the glow lingers on—was a great success. All who attended enjoyed the weekend, in spite of a little rain that discouraged the golfers. There was much merriment and eating; the tour of the Colonial Village kept everyone busy, with its quaint shops.

Of special note: Esther and **Dick Hinchcliff** celebrated their 40th Wedding Anniversary on November 3. We hope they will celebrate many more, perhaps at future reunions! From Anne Ida and **Marty King**, who also attended: "We retired on June 28, 1984, from 40 years in the engineering/steel construction business and 18 years for Anne Ida as an elementary school media and computer specialist. Great careers, but we *don't* miss them. We live at 'Spruce Creek Fly-In' an aviation community just outside of Daytona Beach, with golf, tennis, a pool, and a great bunch of inmates. We own a Cessna 310 and go all over in it. Still love to scuba and take underwater pictures. Our three children are married and we have five grandchildren. We spend some time with our computers, we tinker around the condo, we travel abroad frequently, and generally have a lazy good time. We do miss our friends from New Jersey. Last May our son Dick, '72, got his Ph.D. from Rutgers in computer science. All three of our kids are in the computer industry. We also celebrated our 40th Anniversary. Quite a month. We've had a fantastic time here at Williamsburg. We will do our best not to miss any future reunions."

So hail to the following who attended: Barbara and **Mario Banus**, Ellaveen and **John Barmby**, Jane and **Bob Barnaby**, Sarah and **Larry Biedenharn**, Charlotte and **Pierre Boucheron**, Jean and **Bill Boschen**, Betty and **Hank Bowes**, **John Breymann**, Anita and **Les Brindis**, Louise and **Bud Brown**, Jean and **John Burdakin**, Rose and **Frank Chin**, Marilyn and **Al Carona**, **Andy Corry** and son Jay, Jane and **Louis Demarkles**, Jackie and **Larry Dowd**, Sue and **Harlow Farmer**, Betty and **Lamar Field**, Beverly and **Sten Hammarstrom**, Mardi and **Paul Heilman**, Esther and **Dick Hinchcliff**, Buz and **John Hull**, June and **John Hunter**, Anne Ida and **Marty King**, Marge and **Sam Lamport**, Jean and **Walter Lang**, Betty and **Sam Morrison**, Jean and **Ed Moyer**, Mary and **Al Picardi**, Cleo and **Bill Ritterhoff**, Milena and **Ed Roos**, Mary and **Jim Ruoff**, Ruth and **Norm Sebell**, Jean and **Stan Smock**, Loretta and **Jim St. Germain**, Mary and **Bob Storrs**, **Melissa Teixeira** and Jim Baird, '40, Mary Rose and **Harry Turner**, Betty and **Bud West**, Helen and **Jim Woodburn**, Doris and **Chet Woodworth**, plus Mary and Bob Devine '47, and Margery and Fritz Dunmire '48. Banus, Biedenharn, Chin, Carona, Dowd and Morrison were first-time Reunion goers.

As for the next reunion, John Burdakin suggests the Dearborn Inn, Dearborn, Mich., which has much to offer too, including the Henry Ford Museum, Greenfield Village, the plusses of Detroit, and the Detroit Metro Airport close by. We are open to suggestions, so send yours along. Our thanks again to the Sebells, instigators of the Mini (Norm does a lot of thinking while in that workshop of his), and the Wests, who coordinated all the plans so beautifully on their end of things without a hitch!—Co-Secretaries: **Andy Corry**, Box 310, West Hyannisport, MA 02672; **Lou Demarkles**, 53 Maugus Hill Rd., Wellesley Hills, MA 02181

46 40th Reunion

It's early November in glacial Colorado, and what do I receive but a glowing account of **Bob Nelson**'s trip to Australia, New Zealand, and Tahiti in August. Aa-a-argh! . . . as Charlie Brown would say. Along with this tome was another journal of his trip to England in October, looking into a job opportunity with British Aerospace after he retires from civil service at China Lake. Bob finally retired from the USNR as commander last March, after putting in his allotted score of years. He and his wife Marianne are "looking forward to the big city life" (after all those years out there in the Mojave Desert). Good luck, Bob, and thanks for all the news. Can you get back for the 40th?

The only other "real-time" item was a notice that **Henry Lloyd**, yet another XVIer, had also retired from the USNR, as captain, "after 30 successful years." Henry is an administrator at Flagler College in St. Augustine, Fla.

Letting my fingers do the walking through the white pages of the 1946 *Technique* and a recent edition of the class roster, a semi-masochistic pastime of mine, I came across some fascinating (to me) tid bits I'd like to pass along:

You know how young most of us V-12ers were when we graduated thanks to the accelerated program? Well, if I can believe the *Technique*, **Alan Gruber,** for one, graduated when he was only 18, and to top *that* off he went on to get his S.M. (in Course II) a year later. Small wonder he's now chairman and CEO of Orion Capital Corp., in case you haven't read this before. My roster lists him as living on Park Ave. in New York, if you'd like to drop in on him. . . . Another very bright chap must have been **Frank Low** who was a Course VII graduate before he was 19. Frank now lives in Chappaqua (love that name), N.Y. and is senior vice-president with Phillips Medical Systems in Shelton, Conn. . . . And I almost missed **Louis Wadel,** a couple of months younger than Frank, who was a Course VIer and who evidently returned to "Big D" (Dallas), from whence he came, and at last note was a special research associate, at the University of Texas, Dallas. Makes me feel mightly humble. Of course there was a flock of "young 'uns" who were still 19 when they graduated, but there isn't room to name them all.

All those mentioned above were civilians, whom I feel I've neglected over the years. But I plan to remedy that in forthcoming class notes, especially if I'm short on inputs from my "uncivil" V-12 colleagues. As Mr. "T" would say: I LET YOU LIVE!!—**Jim Ray,** Secretary, 2520 S. Ivanhoe Pl., Denver, CO 80222

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Bob Horowitz, our reunion chairman, fresh from his triumph as chairman of the Newport Tri-Class Bash, and with the help of your indefatigable reunion committee, is proceeding with plans for a fantastic 40th in Bermuda. But never fear, you stay-at-homes: as always, we plan to be on hand for our very special tables at Pops, and for Technology Day, which will include presentation of our 40th Reunion Gift at the luncheon.

We have all received the letter from **Claude Brenner** and **Harl Aldrich** formally announcing our 40th Reunion Gift campaign, with a goal of $3,000,000 and a project focus on the Class of 1947 Professorship. If 70 percent of the class does indeed join in this effort, as is hoped, we shall certainly set a record for a 40th Reunion Gift, as we did with our 25th Reunion Gift in 1972. Better yet, we shall give a succession of M.I.T. professors the extra time for students and teaching that comes with an endowed chair. Remember, our gifts for five years before and our pledges for five years after our reunion date are counted in the 40th Reunion Gift. All aboard!

Norm Holland has been traveling and lecturing in Melbourne and Adelaide, Australia. The Yale University Press has published his book *The I*, a theory of personality. . . . **Ken Block** is now chairman of A.T. Kearney, Inc., Chicago. . . . **John A. Hugus,** of Watsonville, Calif., died in April 1984, according to a note from Mrs. Hugus. . . . Mrs. Sampson writes that **Elmer B. Sampson,** of Leesburg, Fla., died in September 1984, after a long battle with a very rare, incurable cancer.

Please, everyone out there, send me some of your good news. New baby? New book? New job? Traveling? Retiring? I look to you to help us all keep in touch.—**Virginia C. Grammer,** Secretary, 62 Sullivan St., Charlestown, MA 02129

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Dave Freedman and his wife Beverly spent three months in Honduras assisting a bakery to increase its sales and profits. The International Executive Service Corp, which arranges for retired executives to assist businesses in developing nations, asked Dave to volunteer his help. In addition to work at the bakery, Dave and Beverly helped some children there. Beverly taught crafts and singing to younger children and English to older children. Dave visited a cancer clinic and brought bread and cookies for the young patients. "It was a most rewarding episode in our lives," says Dave, "even though I worked harder and more hours per week than I ever did in the States." . . . **Joseph Walters** took early retirement from Hughes Aircraft in 1981. He and his wife live in Oceanside, Calif. and take biannual sightseeing motorhome trips to their summer home on Cape Code. . . . **Jerry Jarrold** writes that his son Bill is a freshman at M.I.T. Bill graduated from Fairfield Prep as a summa cum laude.

In 1983 I had the pleasure of spending 14 days trekking in the Himalyan Mountains near Mt. Everest. This year I returned and during 26 days walked more than 70 miles, climbed a total of five miles (and descended), reaching at the highest point 18,188 feet. I spent seven hours walking and climbing beside the Khombu glacier, which descends from Mt. Everest and is several miles long. From the summit of a small peak called Kala Pattar, I was able to look down on the glacier and observe its overall impact and size, as well as the effect of other glaciers flowing into the Khombu.

The view from Kala Pattar and many adjacent peaks is overwhelming. Nature has sculpted into the mountains every shape, angle, and surface that the mind can imagine. The steepest faces are exposed rock that looks black against the mass of snowfields, cornices, and some faces that have snow remaining despite repeated avalanches.

I slept at Gorak Shep (17,000 feet) for two nights in a tea house (lodge) with 20 other people squeezed into an area 16 by 20 feet. A bowl of Sherpa stew (42¢) and a plate of boiled potatoes (48¢) washed down with milk tea (18¢) provided energy and health. At least every third day, I had dahl bot (rice and lentils) to assure sufficient protein. During and after dinner, I talked with Sherpas who were leading treks, and with other men who herded trains of yaks carrying produce or mountaineering supplies. My Sherpa carried about 60 pounds of my gear, most days, but for two days he carried 85 pounds. He enjoyed my practice of celebrating all major and minor events of the trip with a bowl of noodle soup, a cup of milk tea, or whatever. On the summit of the highest point, we had candy, biscuits, smoked oysters, and beer.

Nepal has a primative way of life by our standards, but the rewards of seeing the mountains more than compensate for any missing comforts. The culture of the Sherpa people is not primitive; they share the values of family and society with which we are familiar.—**Marty Billett,** Secretary, 16 Greenwood Ave., Barrington, R.I. 02805, (401) 245-8963

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Richard S. Holmgren, Jr., has recently been appointed president and chief operating officer of James M. Montgomery, Consulting Engineers, Inc. Dick joined the firm in 1958 when they had about 60 people. Since then, it has grown to its present size of 650-700 employees and has 18 offices nationwide and internationally. The firm has been fortunate in having attracted some outstanding graduates from M.I.T. over the past five years, and they are doing an excellent job in helping to maintain the company's reputation for engineering excellence. Dick's experience with Montgomery has included technical responsibility for design of a number of water treatment plants, primarily for domestic and municipal clients; service in Jamaica and Brazil as project engineer on major water projects; responsibility for opening and managing a new branch office in San Diego; responsibility for overseeing all branches of the company; regional manager of Montgomery's southeast (U.S.) region, and chief operating officer responsible for six operating groups. Dick says **Ken Olsen** will be happy to know that Montgomery has three of his VAXs and internal network between offices is primarily DEC. Dick also has a DEC Rainbow PC at home.

Chester E. Claff, Jr., Ph.D., writes that at last he has found his niche—translating technical German and French documents into English as a free-lance operation. His Commodore 64 word processor supplies the product to clients instantly, from coast to coast. He would be pleased to hear from his former classmates. Leave messages for Claff in his MCI mail inbox.

We regret to report the death of **Kent Moore,** who died on July 30, 1985. He was a professional licensed engineer in Connecticut and was associated with the Electric Boat of General Dynamics Division in Groton for more than 28 years as a nuclear engineer, retiring in 1981. . . . **James J. Beach, Jr.,** died August 27, 1985. Mr. Beach lived in Garden City, N.Y. . . . Professor **Robert W. Mann** informed us of the death of **Robert E. Wohler,** who died suddenly on October 12, 1985. Professor Mann eulogized Bob as follows: ". . . a loyal M.I.T. alumnus, a conscientious and effective volunteer on behalf of the Class of 1950—most recently as a member of our 35th reunion committee—and a good friend. Those of us who participated in our June reunion on campus and later in Bermuda treasure that most recent memory, as well as all our other interactions with Bob and Helen. We will miss him very much." Bob was Polaroid's environmental program manager for the past six years and had retired recently after a 33-year career.—**John T. McKenna, Jr.,** Secretary, 9 Hawthorne Pl., 10H, Boston, MA 02114

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Kenneth L. Bjork retired last March after selling the construction company (Bjork Builders, Ltd.) to his two sons and another young man. He and his wife are living year-round in North Hero, Vt., an island in Lake Champlain about 15 miles from the Canadian border. Kenneth indicates he is trying to shoot his age in golf (in 30 or 40 years). . . . After two cataract extractions, a detached retina, and three years in Delray Beach, Fla., **James Howland Ballou** has returned to Salem and reopened his practice in architecture. He would like to hear from any of his Course IV classmates.—**Gregor J. Gentleman,** Secretary, 600 Holcomb, Suite 1, Des Moines, IA 50313

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Our class president, **Art Turner,** writes, "Last week I toured the Southeast; among other places, I visited the University of Alabama at Birmingham, where an old friend is now a professor. You may remember **Bob Wernikoff,** who is now, and has been for almost two years, professor and director of cardiovascular physics research in the Department of Medicine/Division of Cardiovascular Disease. His activities consist of research, lecturing, and other activities in support of the Division of Cardiovascular Disease. Bob's research involves ways to improve diagnostic imaging methodologies through better signal handling, signal-to-noise improvements, etc. In response to my direct question regarding the courses he teaches, Bob says there are none. And, although he appears to have become an enthusiastic resident of Alabama, he still has no southern accent.

We have a letter from Lucy Miller of the Student Financial Aid Office, telling us about the second Class of '52 Scholar: "Because we do not have a direct descendent of the Class enrolled as an undergraduate this year again, we have chosen Reed Steinmetz, '87. Reed is from Havertown, Pa., although he was born in Lawrence, Mass. He is a junior in chemical engineering, but has been heavily involved in an Undergraduate Research Opportunities Program project under the direction of Professor Papert in architecture. The project they are pursuing involves children and the computer culture, studying the impact of learning cognitive styles, and social and interpersonal understanding. Reed says, 'the research requires programming, writing, speaking, and other creative tasks.' Reed also has an interesting research project under Professor Brown in chemical engineering. This is a complex computer graphics job, and Reed is working for credit rather than pay for this academic year. In his spare time, Reed rows as a member of the Varsity Heavyweight Crew Team, which requires at least 15 hours a week of practice. We are proud to present Reed to the Class of 1952 as this year's Scholar." Remember, the Class of '52 scholarship fund needs our continued financial support. Even though there may be no descendent of a class member who is both bright and needy, there will always be students like Reed who deserve our encouragement, and whom we may regard with pride as proxy descendents.—**Richard F. Lacey,** Secretary, 2340 Cowper St., Palo Alto, CA 94301

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Of some interest to the class, perhaps, is the fact that, in reviewing the class roster recently, I counted 78 classmates who list themselves as president (or the equivalent) of their companies. That's almost 11 percent of the folks on the list published at the time of our reunion in 1984. Since the list contains many names without titles or addresses and since others may have assumed such titles in the last year and a half, the current percentage may well be much higher. I noticed only one dean on the list. If any of you can identify that individual, I'll publish your name in this column, *if* you also send me some news about yourself.

Andrew Kariotis has resigned as president and CEO of Alpha Industries, Inc., in Woburn, Mass., according to information received recently. I took that into account in the above comments.

Finally, our sincere sympathies go to **Joel White,** whose father, the well-known writer E. B. White, died recently.—**Edwin G. Eigel, Jr.,** Secretary, 33 Pepperbush Ln., Fairfield, CT 06430; **Joseph P. Blake, Jr.,** Assistant Secretary, 74 Lawrence Rd., Medford, MA 02155

55

Greetings from the co-anchor in the west of your new reporting team for the next five years. **Bob Greene** caught me in a weak moment, but I am delighted to serve in this capacity. I, too, offer my congratulations to **Allen Schell** and **Marc Gross** for the exceptional job they did over the more than ten years.

I wish I could start on a more positive note, but I have the sad duty of reporting the death of **Paul M. Starch** in Germany. There was little information given as to cause or date of death. His listed address was 136 Oler Elchinger, Tulronweg, West Germany.

Members of our illustrious class continue to move onward and upward. **Mario de Figueiredo** has joined Golden DIPT Co. of St. Louis as vice-president for research and development. In this position he will be responsbile for both new product development and customer service laboratories located in St. Louis and Melrose Park, Ill. Mario was previously with Ralston Purina Co. as technical director of food enterprises. For those who didn't know, Mario has four degrees, three from M.I.T. (S.B. in chemistry and S.M. and



Robert D. Cutkosky, '55, right, and Lai H. Lee, of the U.S. Department of Commerce's National Bureau of Standards, receive an I-R 100 Award. The award is given by **Research and Development** *magazine for the 100 most significant technical developments of the preceding year.*

Ph.D. in food science technology) and an M.B.A. from the University of Chicago. Mario and his wife, Mimi, live in Chesterfield, Mo. and have one child.

Bernhardt J. Wuensch has been named the first professor to occupy a chair established by Japan's TDK Corp. through a gift to M.I.T. of $1 million. This chair is designated the TDK Professorship in Materials Science and Engineering. Professor Wuensch is one of the Institute's most accomplished teachers and an authority on ceramics and crystallography. He holds three degrees from M.I.T.—S.B. and S.M. in physics and a Ph.D. in crystallography—and has been at M.I.T. his whole career with the exception of two years at the University of Bern, Switzerland.

I read in the *Wall Street Journal* that **Stefan Geiringer** was named executive vice-president and chief operating officer of Cogenic Energy Systems, Inc., of New York. Stefan was president of the Utility Systems Corp., a subsidiary.

Bob Greene gave a full report on all the new officers and assigned me the job to report on my happenings. I am currently living in San Marino, Calif. with my wife Nancy (30 years in February). We have three children. Steven is married and lives in Green Bay, Wis., where he works for Proctor and Gamble. Brad is living in Los Angeles and is an accountant executive for AT&T Communications, and daughter Julie is in the process of graduating from the University of San Diego. I am an executive vice-president for Security Pacific Corp. and chairman of Security Pacific Automation Co. This company is a wholly-owned subsidiary of Security Pacific and does all the data processing for the parent, plus sells services to other organizations. I have been at this for almost nine years, a record for me. We enjoy California so I hope to do this for many more years.

That's it for now. Please let me know what you are doing!—**DuWayne J. Peterson, Jr.,** Western Co-Secretary, 1841 Warwick Rd., San Marino, CA 91108; **Robert P. Greene,** Eastern Co-Secretary, 37 Great Rock Rd., Sherborn, MA 01770

56 30th Reunion

Charles C. Joyce, Jr. is president of Network Strategies and former vice president of Richard L. Dael and Associates. He has also worked for the Mitre Corp., the Executive Office of the President, and managed significant consulting assignments for commercial and government clients. In addition he has taught numerous data communications seminars and is on the advisory board of Systems Technology Forum.

Our incoming news is very sparse . . . write or call us. When we see you at the 30th this June we'll have an opportunity to catch up on the news. We're looking forward to seeing *all* of you at the reunion. Have you sent in your registration form?—Co-Secretaries: **Robert Kaiser,** 12 Glengarry, Winchester, MA 01890, (617) 729-5345; **Caroline Disario Chihoski,** 2116 W. Davies Ave., Littleton, CO 80120, (303) 794-5818

58

Welcome to '86. Hope that after the stormy fall and winter season you're heading for some sunny vacation spot this spring. Here's what's hot from the '58 class world. At the Draper Laboratory, **John Deyst** has been appointed associate head of the newly-formed automation technology department. This group will integrate a number of previously separate functions including automation systems, robotics and assembly, and integrated systems and controls. . . . **Richard Nyder** was made product marketing manager at Data IO Corp. in Redmond, Wash. Richard and Penny are still living in Everett, Wash. with their children Katrina (15) and Derek (13).

Congratulations are in order to **Daeyong Lee,** who has received tenure at Rensselaer Polytechnic Institute as a professor in the department of mechanical engineering, aeronautical engineering, and mechanics. He has been associated with the General Electric Research and Development Center for a number of years, and has also authored numerous research articles. . . . Also in the academic world, **Elisabeth Drake,** chairperson of the chemical engineering department of Northeastern University, has been named acting dean of the College of Engineering for the 1985-86 academic year. When Elisabeth was appointed department chairman in 1982, she became the first woman in the U.S. to chair the chemical engineering department of a major university. She was recently the keynote speaker at a conference hosted by Northeastern's College of Engineering, marking the 60th anniversary of women in engineering at the university.

Charles Gorodetzky, M.D., has been promoted to head of the neuro-pharmacology section in the department of clinical neurosciences at Burroughs Wellcome Co., a pharmaceutical product manufacturer in Research Triangle Park, N.C. Charles received his M.D. from Boston University School of Medicine and a Ph.D. in pharmacology from the University of Kentucky. He resides in Chapel Hill. . . . **Arnold Amstutz** is now executive vice-president and a member of the management committee of Advest Group, Inc. in Hartford, Conn. Previously, he had been chairman of ISIS Systems, Inc. . . . Several months ago, on a flight to New York City, I ran into **Bob Schwartz,** who is commuting between Boston and New York to his position with Manufacturer's Hanover Trust Co. Bob is a senior technical officer in the corporate telecommunications department.

Have you noticed, friends, that every place you shop now the clerk seems to ask, "Is that it?" Well, this is it . . . at least until next time.—**Michael E. Brose,** Secretary, 534 East Broadway, South Boston, MA 02127

61 25th Reunion

Hall Bowers sent me a very pleasant letter from Rancho Palos Verdes, Calif. He reports that his marriage to Marie Quinn is fast approaching its 25th anniversary. The Bowers have a couple of daughters: Cathy who just graduated from California State at Bakersfield and Tina who is going to Cal Poly in Pomona. Hal is director of technology in the Industrial Electronics Group at Hughes Aircraft in Irvine. He lives a remarkably varied life. He plays bassoon with the Peninsula Symphony—a semi-professional orchestra, writes articles on travel for the local paper, travels all over the world taking photographs, and likes to fish in every kind of water. His capture of a 170-pound marlin makes me drool.

Sam Lord, an actuary from Course XVIII, mathematics, who works for Phoenix Mutual Life Insurance in Hartford, Conn. has moved up a couple of notches on the corporate ladder to second vice-president. He is in charge of pension planning and analysis. . . . **John Reed,** chairman of Citybank is now on the M.I.T. Corporation.

John Sununu, governor of New Hampshire, spent a little time at M.I.T. last September. First he was the Robert Richards Lecturer and contrasted life as an engineer and as a politician. He pointed out that engineers seem to know the difference between 10 and 1,000,000,000 while. . . . The next day John and his wife Pat joined about 30 local '61ers at a class cocktail party to hear **John Deutch,** provost, and **Gerry Wilson,** dean of engineering, talk about the future of the M.I.T. undergraduate curriculum. **Ira Jaffe** announced that our class gift will go into three funds—one in memory of **Clarke Swannack,** one to honor Howard and Helen Bartlet (former Burton House residents), and the third an Alpha Pi Student Financial Aid Fund. The emphasis is on helping future undergraduates.

Reunion plans are nearly complete. Its been fun hearing about the problems of getting an adequate place for our Saturday dinner-dance. First we thought the Kennedy library would be nice. Unfortunately they want everyone out by 10 p.m. No one thought we could convince you people to leave any time before midnight, and the thought

of the Boston police being called was, while amusing, too much of a return to our undergraduate days. The Museum of Fine Arts seemed just fine until we learned that they could only take about 100 people. That would put about 200 disgruntled men, women, and children in the lobby eating out of boxes. There are many ideas in the works at this writing and we will let you know how it all comes out.—**Andrew Braun,** Secretary, 464 Heath St., Chestnut Hill, MA 02167

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I got a newsy letter from **Yves Berube**. He's minister of higher education for science and technology of the Province of Quebec. Yves graduated as a metallurgist, stayed at Tech to get his Sc.D. four years later, then moved back to his native Canada to teach at Laval University in Quebec. "After supervising some 25 graduate theses, having spent ten years at it, I became restless and switched to politics with the nationalistic Parti Quebecois," he says. Ten years ago Yves became a member of the provincial parliament and occupied a series of offices, including minister of energy, mining and forestry, and education.

So, after two careers—academe and politics, but what's the difference?—Yves is ready for change: "I again feel like a bird about to fly away. I'll let you know, hopefully before 22 years." He and his wife, Francine ('65), are still together after the many years, have two daughters in university, and live in "gorgeous Quebec," at 864, rue Bellevue, Sainte-Foy G1V 2R5.

I have, unfortunately, to report the passing of **Allen Tunick** on August 2, 1985. He and his wife, Jane, lived at Oak Rd., Rt. 3, Box 197, Boonton, NJ 07005. No other information about Allen is available, and this column would welcome information from any reader who knew him, to share with his classmates.

David Junker reports that he and two older alumni, whom he does not name, have founded a high-tech machine-vision company. They plan to roll out first products this spring (a printed-circuit board inspection device and later a Pap-smear analyzer and a hospital image-processing station). David reports he is now broke as a result of investing all his savings in the new venture. Good luck—tell us how things work out and how we can get in touch with you to buy some product or just chat.

Has anyone else out there had, like **Yves Berube,** two or even more careers? If so, let us all know—write or phone: **Phil Marcus,** Secretary, 2617 Guilford Ave., Baltimore, MD 21218, (301) 889-3890

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The reminder from the editoral staff of the *Review* said this is the February/March issue, so Happy Groundhog/Valentine/President's Birthday/St. Patrick/St. Joseph Days. Few people other than those for whom he is the namesake, know much about the last of the above—contrary to occasional rumor, he is not the patron saint of aspirin.

Enough nonsense; on to the news. The first item is a brief Alumni Fund note from **Jerry Dassel.** He was recently appointed vice-president for marketing and research of American Strategy Metals, Inc. ASM, Inc. is a public company headquartered in Monument, Colo. that is engaged in reclamation of strategic metals from specialized scrap. Congratulations, Jerry!

I recently had the good pleasure of spending an evening with **George Piotrowski** who was in Washington attending an automobile safety conference. George is on the faculty at the University of Florida specializing in biomechanical engineering. He has also established a consulting firm to provide analyses and expert testimony in court cases involving automobile accident liability. The firm's name is Design/Analysis Services Co. George has some absolutely fascinating stories to tell about applying simulation and other techniques to reduce the likely cause of injuries in accidents. He has developed specific expertise in understanding the beneficial effects of using seat belts. George and his wife Linda continue to enjoy living in Florida with their two sons, Mark and Eric.

On a trip to Boston last month, I participated in festivities and a symposium in honor of Professor Dave Frisch of the physics department. All of his grad students got together with Dave at the Faculty Club for an evening of good times and fuzzy recollections. Among the celebrants was **Ed Shibata** who was a fellow senior thesis person and grad student in the Synchrotron Lab in Building 24. Ed is now a professor of physics and high-energy physics researcher at Purdue University. Ed's wife Frances attended the symposium as well. She is a native of Saugus, although she and Ed didn't meet in Massachusetts but at a football game at Purdue. Mere mention of the town of Saugus brought forth instant memories of Arnie "Woo-Woo" Ginsberg and the Adventure Car Hop on Route 1. (Now there's something that most of you haven't thought about in a long time!)

The U.S. balance of payments wasn't helped very much by a trip I took to Europe last month to take delivery on a new car. Countries visited included West Germany, Austria, Liechtenstein, Switzerland, and France, although at 120 mph on the Autobahn some of the visits didn't last very long. It was my first trip across the Atlantic; the architecture, museums, food, and just about everything else were wonderful.

Please send news of your activities and also please visit or call if you are in or near Washington.—**Joe Kasper,** Secretary, 3807 Benton St., N.W., Washington, DC 20007

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John Woods was promoted last summer to professor in the department of electrical, computer and systems engineering at R.P.I. . . . **Mike Adler** was elected a fellow of the I.E.E.E. He was cited for his contributions to improved understanding of the device physics of both signal level and power semiconductor devices, as well as development of computer-aided design models and tools for use in semiconductor device design. Mike is a manager of the Power Electronics Laboratory at the General Electric Research and Development Center in Schenectady. He joined the Center in 1971, after completing his Ph.D. in Course VI. . . . **Dick Nathan** has been named a technical director at Batelle Memorial Institute's Columbus Division. The new appointment is in addition to Dick's current position as director of programs. Dick is responsible for large multi-million dollar projects that draw together experts from several technical disciplines. He has been at Batelle since 1970, and has served there in management positions in chemistry, environmental, and physical sciences.—**Steve Lipner,** Secretary, 6 Midland Rd., Wellesley, MA 02181

66 20th Reunion

Robert D. Large, '66, Course III, died suddenly on December 11, 1985 of liver and kidney failure. He was 41. Bob was a member of Lambda Chi Alpha and was president of the Interfraternity Conference, 1965-66. His son William has been accepted into M.I.T.'s Class of '90. A memorial fund has been organized to donate a substantial gift (probably a scholarship) to the Institute in Bob's memory. If you would like to participate, please contact one of the following persons: **Logan Donnel,** Boulder, Co., (303)442-7050; **John Freeman,** Washington, D.C., (202)362-7583; **Dick Hawkes,** Winchester, Mass., (617)729-8131; **P. C. Lindsey,** Lafayette, Calif., (415)284-7804.—*S.K.* **(Joe Shaffery,** Secretary, 34 Hastings Dr., Ft. Salonga, NY 11768)

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Believe it or not, planning our 20th year reunion has begun. A group of our classmates living in the Boston area, including **Jeff Wiesen** and **John Rudy**, have met and are strongly considering holding the reunion off campus at a resort location near Boston, in New Hampshire or on Cape Cod. If this alternative is chosen, the location would probably have to be booked in the near future. Anyone interested in helping plan the reunion should get in touch with either Jeff or John. Jeff can be reached at Mintz, Levin, Cohn, Ferris, Glovsky, and Popeo, (617) 542-6000, the Boston law firm that he joined after law school.

Jeff practices corporate law, with most of his clients being high technology companies, both established firms and start-ups. John can be reached at Raytheon Co. in Bedford. John also passed along some news about two classmates that he and Janice visited last August during a vacation in the Midwest. John and Janice must be great baseball fans, since the classmates they visited live in the Missouri cities and later made it to the World Series. They stayed with Carol and **George Starkschall** and their two children in Kansas City for a few days, and traveled with them to Silver Dollar City, which John describes as a cross between an Ozark Old Sturbridge Village and Disneyland. The Rudys then made a timely visit to Nancy and **Ed Geltman** in St. Louis ("Nancy was very pregnant and delivered Joshua the next day.") Ed, an associate professor of medicine, is back into rowing, both sweeps and sculling, which keeps him busy when he isn't working at Barnes Hospital and Washington University. Nancy works for Metropolitan Life Health Care Management Corp. as director of operation group support.

In July **Barbara Desmond Gilchrest** was appointed professor and chairman of the Department of Dermatology at the Boston University School of Medicine. She retains her laboratory at the USDA Human Nutrition Research Center on Aging at Tufts University. Research, teaching, patient care, and three sons (ages 10, 7, and 1) keep her very busy. . . . **Alex Wilson** is a supervisor of product research for Lukens Steel's research division in Coatesville, Pa., the company he joined in 1974. He is a member of several professional groups and was recently named a fellow of the American Society for Metals, based on his research in non-metallic inclusion structures and fracture mechanics technology. He and Elizabeth have two sons. . . . **Richard Zvonar** writes that he is planning to return to M.I.T. for a few months beginning in February. He and an associate, Diamanda Galas, will be artists-in-residence working on her opera, *Masque of the Red Death*, at the film and video section. Since they need accommodations near campus, anyone who might be of help should contact Richard at P.O. Box 884923, San Francisco, CA 94188 or through Professor Richard Leacock of Film Video at M.I.T., who is their sponsor and collaborator.

Chuck Kolb has been promoted to president and chief executive officer of Aerodyne Research, Inc. in Billerica, Mass. He joined Aerodyne in 1971 after receiving his Ph.D. in physical chemistry from Princeton. He holds academic research appointments at Harvard's Center for Earth and Planetary Sciences and M.I.T.'s Spectroscopy Laboratory.—**Jim Swanson,** Secretary, 878 Hoffman Terr., Los Altos, CA 94022

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John Usher is at Brookhaven National Laboratory, where he finds himself laboring for the N.R.C. in fire protection. He writes, "After fusion and Star Wars (of the Reagan kind), it seems a bit dull." . . . **Hal Varian** was recently appointed to an endowed chair. He is now the Reuben Kempf professor of economics at the University of Michigan. . . . **Carolyn Dedrick** is at Harvard Medical

Five minutes before this picture was taken last May, Owen D. Franken, '68, left, had unexpectedly encountered his classmate Stephen Kanter, '68, in the Beijing railroad station. Franken was in China as a professional photographer, Kanter (shown with his son, Jordan) to teach at Beijing People's University on leave from the Lewis and Clark University Law School.



PHOTO: © DAGMAR FABRICIUS

School as an instructor in diagnostic radiology at Massachusetts General Hospital. Her third child was due in September. . . . **George Claflen, Jr.** has just completed the second of his three years as chairman of the Department of Architecture at Temple University. He writes, "I'm still saving the 'Sun Angle Calculation' I borrowed from **Maria Kivisil** in 1969. Where are you, Maria?"

Michael Laird is now vice-president of marketing for International Laser Machines Corp. in Indianapolis, Ind. He writes from "Naptown," "We make the best industrial laser machining systems in the world for drilling, cutting, welding, and marking. I'd like to hear from alumni in the Indy area or from anyone who wants to get lit up with a laser." . . . In May, the board of directors of Arthur D. Little elected **W. David Lee** a vice-president of the international management and technology consulting firm. He has been a manager of the Engineering Sciences Section, specializing in product design and development of consumer and medical products and special military and aerospace hardware applications, with a focus on cryogenics and advanced fluid machinery.

I procrastinated just a few days too long and missed the last two issues. My apologies to those who invested such confidence in me for this high office. The deadline pressure as a writer/broadcaster for Voice of America science makes work much tougher than it ever was in engineering, but for me it's a labor of love. Just finished a piece on META, the 8.4 million frequency channel receiver now listening for signals from extraterrestrial civilizations. Steve Spielberg donated $100,000 to the Planetary Society and got the project under way. Highlight of my coverage was having Steve autograph my kids' E.T. doll, just before he drove away in his limo. Tune in to V.O.A. for New Horizons, Sundays at 8:10 P.M. Eastern Time (5.995 MHz).—**Eugene Mallove**, 11902 Paradise Ln., Herndon, VA 22017

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John Compton returned after graduation to his native San Francisco Bay area and was awarded a Ph.D. in biophysics at Berkeley in 1979. He and his wife, Sheila, are returning to Bar Harbor, Maine, with their two daughters, where they will work at the Jackson Laboratory. John specializes in studying gene regulation. They lived in Houston when he was at the Baylor College of Medicine doing post-doctorate work and she was commuting to the University of Texas Medical Branch. . . . **Stephen Terry** has a new job as manager of research and development for Transensory Devices, Inc., in Fremont, Calif. . . . Bruce Johnson is vice-president of marketing at Scan-Optics, Inc., in East Hartford. He has an M.B.A. from Harvard; he will be responsible for pricing product planning and product communications. . . . **Martin Langeveld** has been named sales and marketing director for Miller Newspapers. He will be responsible for advertising, circulation, sales, and marketing programs of all Miller productions, which include several daily and weekly papers in western Massachusetts, New York, Vermont, and Connecticut. He, his wife, Beverly, and two children live in Lanesboro; previously, they were innkeepers.

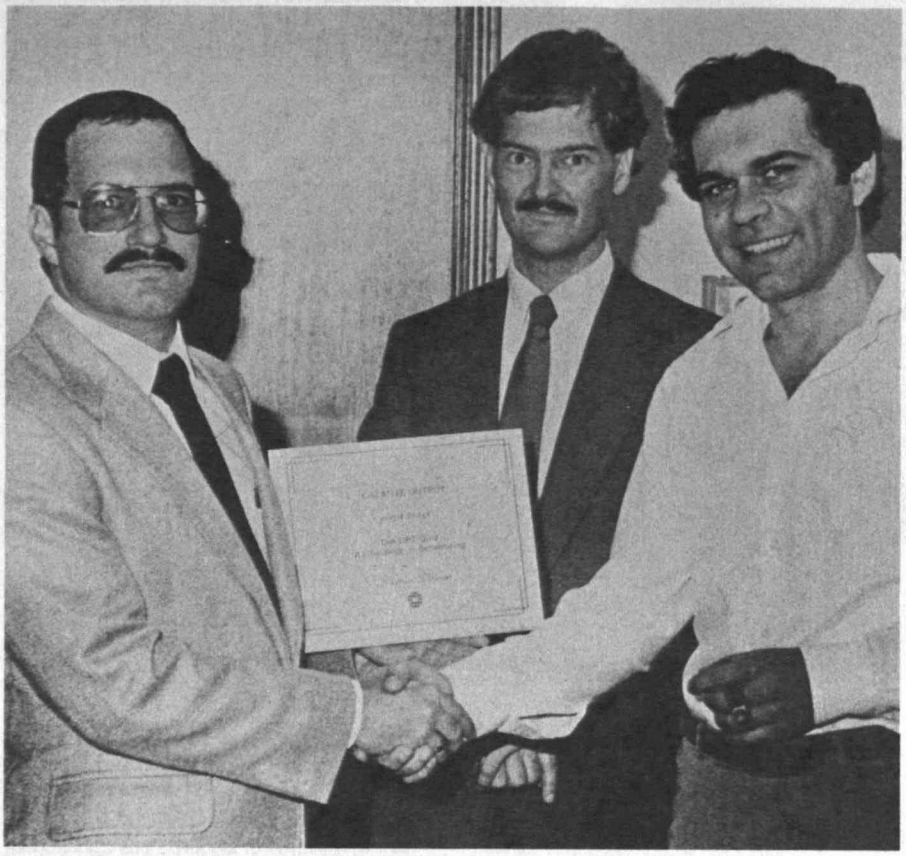
Neil Colvin founded Phoenix Software Associates, Ltd., which specializes in system design solutions for microcomputer manufacturers. It has developed various hardware and software packages, including consultation and product support services. Previously, he was vice-president of software development at Xitan, Inc., one of the five original U.S. microcomputer manufacturers. After that, he was manager of systems programming at the Federal Reserve Bank of Boston and received a master of science in computer science from Harvard. . . . **Alan Chapman** was promoted to associate professor of music at Occidental College in Los Angeles, Calif. He has been a faculty member from 1978; his expertise includes the theory of harmony, and he coordinates a performing jazz ensemble. He has also composed instrumental, theatrical and soundtrack music. He has a masters and Ph.D. in music theory from Yale. . . . **Janet Mangold Landwehr** has become an ordained minister of the Lutheran Church in America and is serving as assistant pastor of Emanuel Lutheran Church in Manchester, Conn.

Raymond Kurzweil through Kurzweil Applied Intelligence, Inc., announced a voice system which is a programmable computer peripheral device that recognizes up to 1,000 different spoken



Joe Bisaccio

words with a high degree of accuracy. . . . A letter from **Joe Bisaccio**, who lives in Wayland: His wife, Karen, has been named a partner in the law firm of Looney and Grossman in Boston; she specializes in commercial law. He has been elected president of Coin Machinery Industry Association of New England, which operates coin-operated vending and game machines. Their son is a sophomore at Rivers School of Weston. . . . We have a letter from **Tom Devine**, who left G.E.'s corporate research and development center after 11 years



For his first place finish in the Opt Quiz, Steve Strauss, '73, left, receives a $5,000 award from Eli Goldratt, right, chairman of Creative Output, Milford, Conn., and Frank Sunderland, contest coordinator. Steve, a mineral economics graduate student at the Colorado School of Mines, was one of over 200 participants in the hypothetical scheduling competition, a quiz developed to emphasize the importance of production management and inventory control.

and has joined the faculty of Berkeley as an assistant professor in the Department of Material Science and Mineral Engineering. He will be designing and teaching undergraduate and graduate courses in corrosion and high-temperature oxidation including associated research. He and wife, Trisha, have three children.—**Robert Vegeler**, Secretary, Beers, Mallers, Backs, Salin, and Larmore, 2120 Ft. Wayne National Bank Bldg., Ft. Wayne, IN 46802

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Paul Hochfeld writes that he is "still working full-time in emergency medicine and taking the national boards to become board-certified in same. Still sheep farming in the coast range of Oregon. I married my yoga instructor. Am learning the need to be flexible and upright, though not necessarily straight." . . . After 13 years as a research chemist at the University of Colorado Health Sciences Center, **Patricia Dearmey** is a full time student at University of Colorado-Denver in the M.B.A. program, with income tax accounting emphasis. . . . **Paul Lentrichia** (the alumnus with the oldest child at the last reunion) is pleased to announce that his daughter won an audition for a part in the Nutcracker ballet in New York. . . . **David Millman** is a student in the Wharton M.B.A. program and will graduate next year. . . . **Roger Putnum** has been appointed co-director of the Center for Optical Sciences at Aerodyne Research in Billerica, Mass. His areas of research include optical signal processing, laser mode locking, and novel semiconductor lasers. He lives in Newton.

Scott Brady is on the faculty of the Department of Cell Biology and the University of Texas Health Science Center in Dallas. . . . **Gerald Zuckier** writes, "After ivory towering the last few years at the Yale Medical School Pharmacology Department (along with Dave Frunk, '80) I have made the big move to the Yale Medical School Physiology Department. Having decided to stay in New Haven, I was promptly visited by Hurricane Gloria as evidence of my good judgment. I heard from Tom Davenport and Kathy VanSant, '76, for all you Bexley relics. They have moved from Back Bay to Maryland. How about word from other Bexleyites? Is everybody a stockbroker now or what?" . . . **Christopher Hill** writes, "I completed my Ph.D. in particle theory at Caltech in 1977, spent two years as a post-doc at Chicago and joined the staff of Fermi National Accelerator Lab where I've happily pursued research and educational activities ever since and now enjoy the luxury of academic tenure. I've become increasingly idealistic as I've witnessed my former colleagues sink into the abyss of materialism. Wish NASA would build the ARK SHIP B. Hello to all former residents of 'boom-zoo'."—**Dick Fletcher**, Secretary, 135 West St., Braintree, MA 02184

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The world of letters seems to have escaped our classmates, for lo this month bears but one, and it's only *about* a classmate, not *from* one. It comes from the public relations folk at the American College of Physicians to the effect that **Ellen Spielman Gitler** has been elected a fellow of that august body. Dr. Gitler, a specialist in internal medicine, is a staff member at North Central Bronx Hospital, and is affiliated with Montefiore and Albert Einstein Medical Centers, also in the Bronx.

We all know that with a membership of some 1,000 little beavers out there, our class must have more to say about itself as it goes through life producing scores of children and exciting discoveries and Lotus Development Corp. Tell us about them!

As for me, I have just this week joined the Alexandria Harmonizers, the barbershop chapter out in Alexandria of SPEBSQSA. They are one of the finest chapter choruses in the society, and are a strong contender to win the international championship this July in Salt Lake City. More on that later. The wife and kids are fine, as usual. How are yours? Write!—**Robert M.O. Sutton, Sr.**, Secretary, "Chapel Hill," 1302 Churchill Ct., Marshall, VA 22115

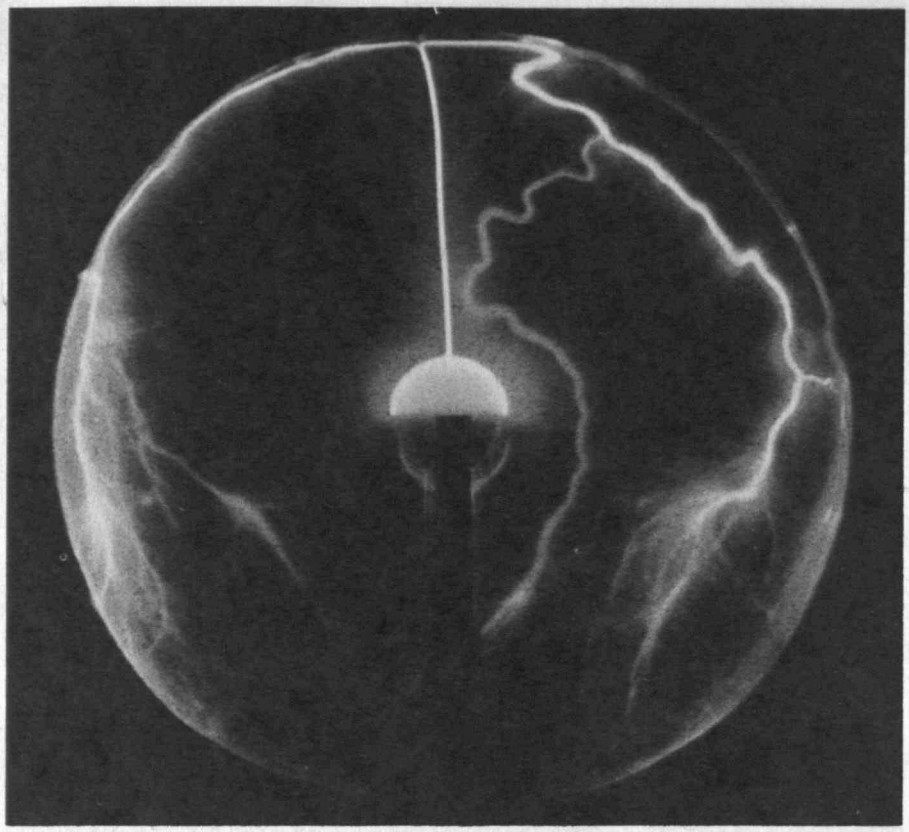
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Harlan R. Davis writes that he has become a home renovator. He and wife Jan recently bought a house and proceeded to gut the insides. Says Harlan, "As of October 1985, most of the walls are back up, the plumbing is done, and one of two (or maybe three) skylights are installed. I have convinced my wife that she knows more about cutting holes in the roof than I do!" Skylights aside, Harlan still works for General Aviation, though he flies a lot less than earlier in his career there. He also manages a small aircraft repair shop. . . . **Paul Graziano** has been working at the Boston Housing Authority for the past three and a-half years. He was recently appointed "assistant administrator for leased housing" by administrator Doris Bunte. Paul had this to say about his job, "Exciting place to be in the post-receivership era!" Paul, like classmate Harlan, is another new home owner, having recently purchased a house in Dorchester after being "astonished and frightened" by the Boston market. . . . **J. Elliot B. Moss** finds it "great to be back in the Commonwealth" as an assistant professor at the University of Massachusetts—computer science, of course!

I received a news release with the headline, "Gordon named vice-president at Packaging Corporation," and since I knew they weren't talking

Art or technology? Bill Parker, '74, combines both in the Parker glass globe, right, a number of which were on display at M.I.T.'s Compton Gallery last October. About 20 different gases go into the globes, says Parker, and they are very expensive to make. "Interactive, kinetic plasma sculptures," he calls them. The globes contain gases and lightening-like charges that change patterns when touched.

The globes are popular—Parker claims to have sold $3-million worth. Some rare editions have sold for $2,800 each. Parkers are in the collections of the Boston Museum of Science, the San Francisco Exploratorium, and the Smithsonian Institution in Washington, D.C.



about me, I figured it had to be about **Ilene Gordon Bluestein**, my freshman year roomate. According to the August 1985 news release, Ilene has been promoted to vice-president for corporate development and diversified businesses at Packaging Corp. of America. Ilene, who previously headed PCA's corporate development group as director, will now head a new operating division, Diversified Businesses, which was formed to explore acquisitions and to manage some newly acquired businesses. Congratulations! (P.S. Ilene, if you're ever in New York, look me up—it's been far too long.)

Finally, while most of us are shivering our way through the winter months, we can think enviously of **Francisco Gutierrez Perez**, who is still working for Bristol Myers Industrial Division in Puerto Rico. He has the position of chemical production manager and, in addition, is responsible for the In-process Control Lab and the Development (In-house) Group. As for family life, says Francisco, "I am happily married to Suzanne Teissoniere with two children."

And on that pleasant note, I will sign off and remind you classmates to keep those cards and letters coming to me.—**Jennifer Gordon**, Secretary, 18 Montgomery Pl., Brooklyn, NY 11215

76 10th Reunion

From the mails, congrats to Dr. **Marsha Lavoie**. Marsha now has her M.D. from the University of California, San Francisco School of Medicine. Marsha and **Larry Hardy** have two sons, Jonathan and Philip.

Greg Hunter is now the soccer coach of Macalester College. He has now had the distinction of leading his team *against* the 'Tute for the opening game of the season. While at the Institute, Greg was the co-captain and MVP in 1975. After graduating, he was teaching math and coaching basketball, soccer, and track at Cushing Academy in Ashburnham, Mass. for two years. He then taught and coached in Durham, N.C., before moving to Macalester in 1983. Such irony, playing against the team he helped to head!

One of the members of the Systems Technology Forum is **Jeffrey Held**. He is also the group manager at Network Strategies, Inc. in the data communications networks area. Prior to this, he did design work as an assistant at Richard L. Deal and Associates.

Sorry these notes are so short. To have a longer column, more of you must write. We are heading towards our 10th reunion, and many of you have yet to send word of your doings. Do not make me wait another ten years for news! It is very easy to put pen to paper and write. Believe me.

As for your secretary, he is nervously watching the DJIA hit 1440 and long-term treasury bond yields test 10 percent. It smacks of "tulipmania." Therefore, I am concerned. As a futures trader, I remain actually aware of the dictum that what goes up must come DOWN. (Nothing in the financial markets ever reaches escape velocity.) Shall we crash, or shall we come in for a soft landing? It remains an exciting, frightening time to be involved with the financial markets. Write. We need the news.—**Arthur J. Carp**, Secretary, 110-07 73rd Rd., Forest Hills, NY 11375, (718)544-5136

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I've missed a few columns, partly because I had next to zero news to report. Thankfully, a few notes have come in, so here we go. By the way, if you were disappointed because '77 wasn't here, then drop me a note so it won't happen again.

Margaret Brandeau completed her Ph.D. in engineering-economic systems at Stanford, and is now an assistant professor of industrial engineering and engineering management at Stanford. She took a "post-Ph.D." vacation for five weeks in South America last spring, going trekking, rafting, etc. Now she has settled down to "publish or perish," taking time out for some outdoor recreation in California.

Elliot Lach and his wife, Tammy Harris, have just moved to a new home in Framingham, Mass. Elliot graduated from Yale Medical School in 1981, and is now in his second year of training in a plastic surgery fellowship at Brigham and Women's and Children's Hospitals in Boston. . . . **Ronald Watro** joined Mitre Corp. in June, and is working on formal specifications and verifications of computer programs.

Our clipping service brought in several items this month. **David Passmore** is a group manager of network architectures and protocols at Network Strategies, Inc., and is teaching with Systems Technology Forum. . . . **Martin Schlecht,** currently an assistant professor of electrical engineering at M.I.T., has been named the first holder of the newly-endowed Kiethley Professorship. David and his wife, Nancy, live in Lexington . . . The engagement of **Richard Potash** and Anne Collins was announced in August. Richard is a computer scientist, working with Computer Sports Medicine, Inc.

Teresa, '78 and **Dan Nolet** had their second daughter, Andrea Clare, in March 1985. Dan and Teresa, Catherine, and Andrea live in Corning, N.Y.

Well, that's all for the last three months. Please drop me a line.—**Barbara Wilson Crane,** Secretary, 6431 Galway Dr., Colorado Springs, CO 80907

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Let's start this month's gossip with **Steve Stein**. Not only is he a doctor, he's about to become a

specialist! But Steve's big news is his recent (June 1, 1985) wedding to the former Ann Landy (they were introduced by **Mike Manes**). Our class was represented by Mike Manes and his wife Jackie, **Gene Henschel, Tom Janson, Mike Reis**, and **Bill Fejes** and his wife. Steve just completed a residency in emergency medicine at the Medical College of Pennsylvania. Now he's paying his debt to Uncle Sam by doing a rotation in emergency medicine in northern Vermont, while Ann is completing an orthopedic surgery residency at the University of Vermont. . . . If all goes well this weekend (mid-November), **Gene Allen** will be a married man by Saturday night. Gene and his bride, Kathy Cox, both work for Booz-Allen in New York City. More details next column.

A small bit of official announcements: Back when he agreed to take over the office of class agent, **Dave Woodruff** set himself the goal of raising $50,000 for the Class of 1978 Student Aid Fund. I'm happy to announce that we and David have met and exceeded that goal. Kudos from the class officers for this awesome performance. The class agent position has now been taken over by **Diane Curtis**, who is shooting for $50k more. . . . Speaking of Diane, she recently left Lotus Development in Cambridge to establish her own software and management consulting firm with her husband, class president **Jim Bidigare**. The firm, which has been in operation since the early fall, is called the Cadence Group. In their first months of operations, they have cornered some big contracts, and things are looking good.

I got a bevy of boring British postcards from **Diane Prignoli**. Diane, an immunologist for the New York City Department of Health, wrote to tell us of her "whirlwind maritime business and pleasure journey." She travelled to Poole, Dorset, Southampton, London (where she presented a talk titled "Sewage Treatment on Board the Staten Island Ferry" to the International Marine Transit Association), and Liverpool to visit various maritime landmarks, run in a 10k marathon and pub crawl around London. . . . A note from **Neil Cronin**: he is "working for Arthur D. Little Program Systems Management Co., consulting on jam-resistant secure radio communications. My expertise is in software engineering, physics and mathematics applied in a sytems approach. In addition, there is an oversight responsibility to manage government and contractor reporting and financial issues."

Tim Reckart writes to tell us that he is assistant general counsel of Orbital Sciences Corp. (president, David Thompson, '77) which makes upper stage rockets for use in the Space Shuttle. Tim's daughter Angela has just turned one year old. . . . Little did we know at M.I.T., but **Elizabeth Whitbeck** is apparently quite an artist. Last March, Elizabeth's painting of the American Southwest and of southeastern Connecticut were given a month-long showing at the Lyman Allyn Museum at New London, Conn. She was quoted as saying, "Most people think engineering and art are opposites and think it strange that one person would be interested in both. But they both require the same type of analytical skills, creativity, craftsmanship and hard work." She adds, "The major difference is that engineering pays more."

Last, and as usual, least, there's me. I'm in my third week as planning analyst at University Hospital in Boston, and if three weeks is any indication, I'm going to love hospital planning. If only they'd move the hospital closer to the Red Line. In the meanwhile, my wife Yuko is tooling away at the 'Tute—just three and a half semesters to go before her M.B.A. is done.—**David S. Browne**, Secretary, 50 Follen St., #104, Cambridge, MA 02138



M.I.T. is well represented internationally by Sy Danberg, '77, left, and Dan Chernoff, '82. Danberg was a silver medalist at the 1985 World Rowing Championships held in Hazewinkel, Belgium last summer, while Chernoff won two gold medals in the single and double sculls at the 12th Maccabiah Games in Tel Aviv, Israel.

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Crawford Smith spent three and a half years with General Electric in Lynn, Mass. He recently started a new job at the Applied Research Laboratory at Penn State University in State College, Pa. He is also working toward a Ph.D. on a part-time basis. In April, Crawford and wife Martha will be giving daughter Caitlyn (2) a new little sister or brother. . . . **Juan C. Torres Carreterro** started a company called Sea Pharm over a year ago. The company screens for pharmaceutically active compounds from marine organisms. Headquarters are in Princeton, N.J. Juan and his wife, Ann, will be moving to Princeton in the spring. . . . **David Fillmore** is a first-year diagnostic radiology resident at the University of Arizona.

Ronald Newman writes, "After an eight-week bicycle tour of Europe in the summer of 1984, I decided L.A. was no longer the place and came back to Boston and M.I.T., where I'm now working for Project Athena. It's nice not to spend half my life in a car any more!" . . . **Richard Bryant** got married last June to Lynn Fabrizio, a nurse from Stratford, Conn. They are now living in their own home in Ashland, Mass. Richard is working as a transportation consultant with Vanasse-Hangen Associates in Boston. . . . **Mark Blosser** is an environmental engineer with the State of Delaware; he is responsible for statewide surface water quality management programs.—**Sharon Lowenheim**, Secretary, 303 E. 83 St., Apt. 24F, New York, NY 10028

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Robert P. Stone writes that he has been reassigned to Tyndall A.F.B., La., where he'll be an F-15 instructor pilot. He says that the Gulf of Mexico sure beats his last assignment in the New Mexico desert. . . . **Laura Robinson** is working for the M.I.T. Industrial Liaison Program. She joined I.L.P. from Merck, Sharp and Dohme in West Point, Pa., where she worked since graduating from the Wharton School in 1982.

From the medical front: **James Karlen** is doing an internship in internal medicine at Roanoke Memorial Hospital. He'll be starting an anesthesiology residency at Mercy Hospital in Pittsburgh on January 1, 1987. He says, "Dekes come visit!" . . . **Charles Lutz** (who was at Boston University Medical School) is "embarking on his training in Otolaryngology (i.e., ear, nose and throat) as a resident at the University of Pittsburgh." He has another four years to go before he's finally out in the real world." . . . **Pat Latterell** just made the big jump from coast to coast. He left his job as manager of corporate development at Syntex in Palo Alto, Calif., to work in venture capital at Rothschild Ventures in New York, N.Y.—**Kate Mulroney**, Secretary, 10 Arizona Terrace #3, Arlington, MA 02174

81 5th Reunion

Aha! I knew we still had a few avid writers left in the class. Let's start with the local crowd here in Boston. Back at the 'Tute is **Marc Chelemer**. Marc has returned from the Linde Division of Union Carbide to become an industrial liason officer. I've also seen a great deal of Marc on the class reunion committee. Marc has been helping with publicity, and he co-chairs the gift committee with **Jeff Solof**. Jeff, by the way, is now once again working at the Alumni Fund and is married to lovely wife, Marta. In addition, Jeff has been ordained as a Greek Orthodox deacon. . . . **Rob Steinberg** is project manager of E15, the arts and media technology facility, which just officially opened this fall. . . . Also at M.I.T. is **Barry Mirrer**—at least in a volunteer capacity. While still working at BB&N at Fresh Pond, Barry was conductor of the MTG production of *Applause* and is now musical director of *Brigadoon*. This school year will be Barry's third year as director of the Wellesley College Jazz Band, Prism. Barry also plays in a saxophone sextet called Your State and

Local Saxes composed mostly of M.I.T. students and grads. Barry writes that he "even eats and sleeps sometimes."

Clifford Heyer is self-employed and is living in Boston. Current projects include DECSYSTEM/VAX 8600 conversion studies for Digital Equipment Corp., a graphics package for National Information Systems in California, and a Horse/Dog racing database system for Sullivan Brothers in Lowell, Mass. I hope Cliff doesn't stay up late one night and get his projects mixed up. . . . Also, in Boston is **Sarah Axel** who's working as a first-year resident in pediatrics at Boston City Hospital. Sarah says that it's good to be "back home after having been back home in Illinois for medical school."

Chun-Chee Lau writes: "Upon graduation from Wharton's M.B.A. program in December 1984, I have joined the Johnson and Johnson Personal Products Co. within its multinational marketing organization. My new job has been interesting, stimulating, and challenging. I enjoy it so far." . . . **Guido DeFever** recently moved to Connecticut from Los Angeles for "better job and real weather." (I know some Californians who would argue that!) Guido has a six-month-old daughter, Erin, and is currently working on an M.S. in technology management. . . . Lisa and **Dennis Gorman** live in Plano, Tex., and Dennis works for Merit Technology in Dallas. Lisa recently gave birth to their first child, Caroline Elizabeth.

Well, that's all the news that's fit to print. Class reunion plans are going great. We're planning a weekend that's light on nostalgia and heavy on good fun and entertainment. I promise all who come will have a great time. By the way, class reunion also means class elections. Please contact me ASAP if you're interested in taking over this very enjoyable duty as class scribe. Regards to all!—**Chuck Markham**, Secretary, 362 Commonwealth Ave., 2E, Boston, MA 02115

83

Hello again fellow classmates! I have not been receiving much mail lately, but from what little I have received and from what my little bluebirds have been telling me, there is always plenty to tell.

Shawn L. Petera was promoted to first lieutenant in the U.S. Air Force. Shawn is stationed at Wright Patterson Air Force Base, Ohio. Shawn and his wife Wendy are enjoying the military accomodations Uncle Sam is providing. Congratulations, Shawn. . . . **John Piotti** is serving as executive secretary for the Massachusett Water Resources Authority Advisory Board. He says he is very excited to have finally reached the working world. . . . **Pamela Hampton Idriss**, who entered with Class of '80 but graduated with our class, writes that she is very happily married to her college sweetheart, Samir Idriss, '81. They live in Mattapan, Mass. and are opening their own business making handmade Christian greeting cards. The remainder of her letter basically blesses our entire class. We all thank you. Good luck with the new company. . . . **Shawn Wilson** has accepted a new position with The California Thoroughbred Breeders Assn. as a computer operator. . . . Several people have written and specifically asked to be Celebrity '83 for the issue. The overall value of this honor has become very apparent. if any of you think that your recent accomplishments merit this added distinction, then please ask. **Terry Sutton** called and begged me to make her Celebrity '83. She admits that she really isn't doing all that much but would like the distinction just the same. Congratulations, Terry, on being selected. I now expect the letter outlining everything that you weren't able to tell me on the phone.

As for myself, it looks like I will finally be buying a house. Since I don't have IBM classes any more, I figured I would make the big move. The house is located in Port Washington Long Island, and I am purchasing it with Albert Bashawaty, '84. Hopefully, by the time you read this I will be in the new dwelling. Please send all letters to the same address below. I will let everyone know when to change. Keep the letters coming.—**John E. De Rubeis**, Secretary, 47 Gillette Ave., Sayville, NY 11782

84

Congratulations to **Katja Seidel** (nee **Mamalakis**) for the birth of a son, Robert Norman. This is an historic event: the first offspring, I believe, of any member of our class.

A few months ago, I received a postcard featuring three photos—a herd of cows grazing, a large bull thoughtfully chewing its cud, and a cowboy lassoing a heifer—with the captions, "Hello from Summit, S.D." and "Beef on the Hoof." Pencilled underneath were the words, "Meet Biff and Buffy." Flipping the card over, I discovered it was from former S.C.C. chairman, **John Mark Johnston**, who apologized for not writing earlier: "I've been meaning to write, but you know how things get. You don't get around to doing things you mean to do 'cause you get busy and some things don't get done. Like writing. No use beating a dead bull, as they say here in South Dakota." . . . A more informative letter comes from **Sho Fuji**. A grad student this past year at Stanford's Material Science department, Sho has "decided to take the big plunge and go for a Ph.D. My research involves developing a SUPREME process model for GaAs." To keep busy, Sho has taken up judo (for the first time in over nine years): "I've already won a couple of local tournaments and have competed on the Stanford judo team in several intercollegiate matches. A big thrill was competing for Stanford in the National Collegiate Judo Championships in April." Sho also notes that Stanford seems popular with M.I.T. alumni—six out of 30 first-year graduate students in his department are from M.I.T., including **Anita Wahi**, **Terry Tatad** and **Bill Mohr**.

Lee Marzke is working for OPTIMA Systems, a small electronics research and development firm in Burlington, Mass.; Lee reports, "Now that I have some money, I have been able to catch up on my favorite hobby—flying. Just received my commercial pilot license from the F.A.A. I am still active in the M.I.T. Soaring Association, serving as chief tow pilot." . . . **James Molloy** laments that he is "struggling through first year in physics graduate school at Carnegie-Mellon University and recently joined the American Physics Society. . . . **Scott Weingaertner** is a candidate from S.M. in technology and policy, working at the Laboratory for Information and Decision Systems and Draper on knowledge-based systems and organizations. . . . **Brett Doehr** informs us, "I moved to Colorado after graduating and now work in the artificial intelligence unit at Martin Marietta Denver Aerospace. Having just completed work on a fault isolation expert system for a satellite propulsion system, I will probably work on the Space Station project." . . . **Karen Welch** reports, "After travelling 2 months this summer around the U.S., I started working in Warren, Ohio. In November, I was chosen to be in an exchange program—four weeks in Germany. In June, my job takes me to Mexico! Other than paying loans for furniture and for my new Fiero, things are going well."

And this concludes another episode in "The Adventures of the Class of '84." Be sure to tune in next time when we'll learn the answers to such pressing questions as "What is **Pat Robertson** doing with little girls?" and "What about **Carolina Leonard** and that gorgeous, independently wealthy man?" The saga continues.—**Peter Tu**, Secretary, 259 Summer St., Somerville, MA 02143, (617) 628-3476

85

Karin Lohman checked in from "Mad City" (Madison, Wisc.) where she is attending the University of Wisconsin. She's been busy studying soybeans, zuchini, worms, and fruit flies with other M.I.T. alumni—**Rex Kochanski** and **Kenin O'Connell**. . . . **Jill Porter** is at Purdue studying agricultural engineering while looking for a "real man" without much luck. . . . **Cathy Smith** has given up the quest for a man at the University of Washington in Seattle. . . . Karin managed to track down **Deb Meinholtz**. Deb is enjoying New Orleans while working for Shell. . . . Deb is not alone in New Orleans: a couple of other classmates are attending medical school at Tulane. **Mimi Yenari** tells me that she and **Kim Adams** are working hard convincing those folks at Tulane that M.I.T. students know how to party! . . . Mimi tells me that **Elizabeth Raphael** is also in medical school, at Wayne State in the Motor City. . . . **Domenic Zamuto** has moved to Harvard Medical School. . . . **Phyllis Chan** is still in Boston.

Laurie Barrett and **Althea Haylett** are working for Mitsubishi in Japan. Althea will undoubtedly achieve notoriety by riding around on a pink and green bike which she recently obtained. She's having fun with other classmates in Japan, but misses her AKA sisters. . . . **Chiquita White** proves to be a valuable source of information. She confesses that Philly just doesn't compare to Boston. However, word has it that Atlanta, Poughkeepsie and Wharton are hopping: **Pam Givens** is working for her M.B.A. at Georgia Tech and claims there are some fine dudes in Atlanta. . . . **Carla Raiford** has been following football in her hours off from work at I.B.M.—she's managed to catch herself a real live Giant! . . . **Leslie Spencer** is also in New York. . . . Chiquita is also in touch with **Willard Stanback** and **Yancy Dennis**, who are at the University of Virginia, studying law and chemical engineering, respectively. . . . **Ishmael Rodriguez** is in the area working for Hewlett-Packard.

Gerry Baron works for Rabbit (a software company) in Malvern, Pa. Gerry managed to get together a number of classmates at a housewarming party and is thoroughly enjoying the bachelor life. . . . **Kevin Marshall** has a super place in Newark, Del., and a new Mazda. He's working for DuPont in process engineering and hanging out with **Gordon Wright**.

Joyce Lee is working in Atlanta for Leo A. Daly, an architecture company. She misses Boston and will be heading back to M.I.T. for graduate school. Joyce has discovered one of the "fine" Atlanta dudes that Pam Givens reported. He is a Harvard graduate whose brother graduated in our class at M.I.T., but she refrained from mentioning the brother's name. . . . **Pat Chin** brought me up to date on his Next House buddies. He's keeping busy at New Jersey Medical School, although he claims it's not as hard as M.I.T. . . . **Dave Baorto** is at N.Y.U. Medical School. . . . **Brian Carty** is at Bowman Gray Medical School.

Steve Pang, **Dave Wu**, **Steve Soares**, and **Boyd Livingston** are living in Waltham. Thanks to Steve for the super t-shirt design we had last spring! In fact, we still have a few left if anyone is interested. . . . **Kip Dee Kuntz** is enjoying beautiful Hawaii, where he is attending the Institute for Astronomy at Honolulu. He has been dubbed "Doctor Dapper" because of his bow-tie trademark. He has come across several '82 alumni—Heidi Hammel, Darren De Poy, and Alex Storrs—who are also studying at the I.F.A.

Things have been rather mellow here in California, with the exception of Halloween night: Jay Keith, '83, and his wife, Donna, had a party at which we attempted to recreate the infamous Scorpion bowl! **Jim Lutz**, Steve Carroll, '84, Eddie Pirog, '83, **Pat Jennings**, **Jeff Winner**, **Andy Weiss**, Tom Rucker, '83, **Libby Patterson** and I were on the official quality control staff. . . . **Adrain Wang** has been busy at work in San Jose and has been travelling to Berkeley. He ran into **Albert Wang** while in Berkeley and they joined some others at Spenger's Fish Grotto.—**Stephanie Scheidler**, 2 Carver St., Apt. B, Somerville, MA 02143

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Thomas B. King, 1923-1985: Distinguished Chemical Metallurgist

Professor Thomas B. King, who was head of the Department of Metallurgy and Materials Science for a decade starting in 1962, died suddenly of a heart attack at his home on November 23; he was 62.

"We have lost a colleague, friend, and gentleman who through his humor, wit and good nature helped us to see the better part of ourselves," said Professor Merton C. Flemings, '51, head of the department that King once led.

Professor King served on the faculty for 33 years, and he was recognized throughout the Institute as a dedicated teacher, deeply concerned with the undergraduate program. He directed the departmental co-op program from its inception under his aegis, and he devoted much of his time to advising and counseling students.

Meanwhile, King also made valuable technical contributions in thermodynamics and the kinetics of such high-temperature systems as steelmaking. He was a consultant on extractive metallurgy and on metallurgical emissions, and he frequently worked with Soviet metallurgists on steelmaking and other industrial facilities in the U.S.S.R.

A native of Scotland, King studied at Glasgow University, from which he held an honorary Sc.D. (1985). He came to the U.S. to join M.I.T. in 1953.



T. B. King

Robert C. Casselman, 1918-1985

Robert C. Casselman, '39, recognized for his leadership in the Boston community as well as his business success and contributions to M.I.T., died at his retirement home in Sanibel, Fla., on November 29. He was 67, and had been in failing health since 1979.

Casselman served as vice-president of the Alumni Association in 1967-69 and began a term on the Alumni Fund Board two years later. Following a successful technical and marketing career at Polaroid, Casselman became associate director of the Museum of Fine Arts. He was also a principal architect of a state government reorganization plan commissioned by Governor John A. Volpe in the 1960s.

Herman Pollack, 1907-1985

Rabbi Herman Pollack, who was the first director of the M.I.T. Hillel Foundation during 20 years' service as a religious counselor at the Institute, died on December 2 at Beth Israel Hospital, Boston, after a long illness; he was 78.

Pollack's career at M.I.T was distinguished by his dedication to enriching Jewish life and culture on the campus. He was a passionate seeker of social justice, strongly committed to pacifism, and he offered his counsel and spiritual support to the entire community throughout two decades that included the period of the Viet Nam war.

Ralph C. Young, 1890-1985

Ralph C. Young, Ph.D.'29, associate professor emeritus of chemistry, died on October 5 in Phoenix, N.Y., at the age of 95. Young served in the U.S. Department of Agriculture before coming to M.I.T. for graduate work in 1921, and later he worked at the Institute as instructor, research associate, and assistant and associate professor.

Deceased

The following deaths have been reported to the Alumni Association since the *Review*'s last deadline:

Alexander M. Emerson, '08; October 15, 1985; Kimberton, Penn.
Stuart Chase, '10; November 16, 1985; West Redding, Conn.
Frank W. Bucknam, '16; October 14, 1985; Auburn, Calif.
Alexander G. MacAlister, Jr., '18; 1985; Haddonfield, N.J.
Theodore W. Bossert, '20; November 24, 1985; Carnegie, Penn.
Josiah D. Crosby, '21; September 28, 1985; Sarasota, Fla.
Mrs. Harold K. Moritz, '21; 1985; Seattle, Wash.
Fairfield E. Ramond, '21; November 10, 1985; Peterborough, N.H.
Norman J. Greene, '22; November 29, 1985; Newton Square, Penn.
William H. Mueser, '22; June 25, 1985.
Winthrop F. Potter, '22; December 12, 1985; Lexington, Mass.
Harry E. Kent, '23; 1985; Darien, Conn.
Howard F. Russell, '23; November 24, 1985; Sun City, Ariz.
Charles F. Schell, '23; September 17, 1985; Braintree, Mass.
Mrs. Ernst A. Guillemin, '24; November 1985; Wellesley, Mass.
William F. Sonnekalb, Jr., '25; September 28, 1985; Summit, N.J.
George L. Diggs, '26; 1985; Cambridge, Mass.
Theodore Taylor, '26; January 18, 1985; Denville, N.J.
Roscoe L. Wood, '26; September 18, 1985; Kaneohe, Hawaii.
Carl H. Anderson, '27; August 21, 1985; Sun City, Ariz.
Sidney E. Blandford, Jr., '27; June 1985; Denver, Colo.
Gustav A. Brunn, '27; October 12, 1985; Raymore, Mo.
Robert W. Carr, '27; April 17, 1985; Batavia, N.Y.
Alfred W. Schuster, '27; October 11, 1984; El Paso, Tex.
Charles Henry Conroy, '28; May 15, 1985; St. Johns, Canada.
John Henry L. Giles, '29; October 31, 1985; Altadena, Calif.
Earl J. LeRoi, '29; August 23, 1985; Omaha, Neb.
Hiram A. Lyke, '29; June 3, 1985; Oconomowoc, Wisc.
George D. Rogers, '29; 1985; Fairfax, Va.
Phil W. Sayles, '29; September 23, 1985; Washington, D.C.
David S. Stanley, '30; 1985; Walnut Creek, Calif.
Loudon C. Page, '31; 1985; Uncasville, Conn.
Leopold C. Tappey, '31; February 25, 1985; Norwich, Conn.
Mrs. Karl Volkhausen, '31; August 1983; Worcester, Mass.
Harold K. Crowder, '32; July 5, 1985; Parma, Ohio.
Donatien L. Dionne, '32; August 31, 1985; Norway, Maine.
Kirk Horigian, '32; November 11, 1985; Birmingham, Mich.
Alwin B. Newton, '32; October 29, 1985; York, Penn.
Edwin B. Powell, '32; June 30, 1985; Woodbury, Conn.
Gardner H. Prescott, '32; 1985; Chambly, Canada.
Nicholas E. Rothenthaler, '32; November 2, 1985; Boca Raton, Fla.
Frederick W. Kressman, Jr., '33; August 25, 1985; Cross City, Fla.
James E. Turner, '33; October 26, 1985; Highland Beach, Fla.
Lynn A. Williams, Jr., '33; April 21, 1985; Winnetka, Ill.
Constant W. Chase, Jr., '34; December 6, 1985; Seminole, Fla.
Charles W. Jerome, '34; October 23, 1985; Marblehead, Mass.
William J. Suchors, '35; March 19, 1985; Jacksonville, Fla.
Charles N. Griffiths, Sr., '37; November 22, 1985; Binghamton, N.Y.
Harold Rosenthal, '38; December 16, 1985; Belmont, Mass.
George J. Stansfield, '38; October 27, 1985; Alexandria, Va.
Robert C. Casselman, '39; November 29, 1985; Sanibel, Fla.
Arthur H. Cook, '39; September 15, 1985; Chatham, Mass.
James E. Seebold, '39; October 3, 1985; Flossmoor, Ill.
John E. Wood III, '39; December 7, 1985; Birmingham, Ala.
Allen G. Craig, '40; August 11, 1985; Dalton, Mass.
Robert D. Fletcher, '41; October 27, 1985; Tubac, Ariz.
Frederick R. Gruner, '41; October 27, 1985; Green Valley, Ariz.
Jose C. Santos, '42; June 15, 1985; Rio De Janeiro, Brazil.
Eugene R. Davis, '43; November 11, 1985; Wellesley, Mass.
David C. Knodel, '47; October 1985; Lexington, Mass.
John M. Griffith, '58; May 20, 1985; Mamaroneck, N.Y.
Doretta Ann Klein, '56; November 3, 1985; Arlington, Mass.
William D. Pugh, '57; August 2, 1985; Alamo, Calif.
Earl M. Kipp, '58; 1984; Denver, Colo.
George N. Yerid, '59; November 16, 1985; Chelmsford, Mass.
Paul M. Hogle, '61; May 31, 1985; Shaker Heights, Ohio.
Robert D. Large, '66; December 10, 1985; Tampa, Fla.
Lucille D. Roseman, '72; November 17, 1985; Lexington, Mass.
Doreen R. Harris, '76; June 23, 1985; Fair Lawn, N.J.
Jay B. Taller, '76; October 11, 1984; Ottawa, Canada.
Gary D. Romano, '86; November 24, 1985; Warren, Ohio.

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ALLAN J. GOTTLIEB

Dog's Mead and Farmer Dunk's Mother-in-Law

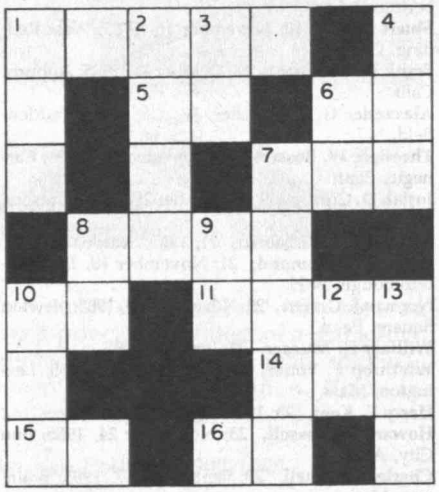
A word on problem backlogs is in order. I have over a one-year supply of both regular and bridge problems. For chess and computer problems the backlog is much smaller—about a half year for each. Finally, a shortage of speed problems has developed.

Two personal comments. Today (Christmas eve) is Phelps Meaker's 85th birthday: happy birthday, Mr. Meaker! And I would like to thank everyone for their kind words concerning my receipt of tenure.

Problems

F/M 1. We begin with a bridge problem from Howard Sard who wants you to construct a deal such that North-South can make 7 no-trump against the worst defense with North-South having the minimum number of high-card points. By worst defense we mean that the declarer can specify which (legal) cards the defenders are to play at each trick.

F/M 2. Peter Defoe has sent us a famous old English puzzle called Dog's Mead. The name sounds familiar, and I wouldn't be surprised to find that I published this same problem 10 or 15 years ago. However, repeating good problems every dozen years doesn't sound like a bad idea. Although it relates to a farmer, his family, and his land, Dog's Mead involves a good deal of engineering math and logic:
The problem is to find the age of Mrs. Grooby, Farmer Dunk's mother-in-law. You'll need to know that there are 20 shillings to the pound sterling, that an acre is 4840 square yards, and that a rood is a quarter of an acre. And you must *not* assume the puzzle was invented this year. Also, these hints help: one number in the puzzle is the area of Dog's Mead in roods, but it relates to something in the puzzle quite different from that area. One of the numbers across is the same as one of the numbers down. All numbers are integers, and no number begins with a 'O'. So here you are . . .



Across
1. Area of Dog's Mead in square yards.
5. Age of Farmer Dunk's daughter, Martha.
6. The difference between the length and breadth of Dog's Mead in yards.
7. Number of roods in Dog's Mead times number nine down.
8. The year when Little Piggly came into occupation by Dunk family.
10. Farmer Dunk's age.
11. The year Farmer Dunk's youngest child, Mary, was born.
14. Perimeter of Dog's Mead in yards.
15. The cube of Farmer Dunk's walking speed in miles per hour.
16. Number fifteen across minus number nine down.

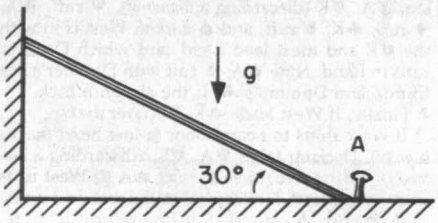
Down
1. The value of Dog's Mead in shillings per acre.
2. The square of Mrs. Grooby's age.
3. The age of Mary.
4. The value of Dog's Mead in pounds sterling.
6. The age of Farmer Dunk's first-born, Edward, who will be twice as old as Mary next year.
7. The square, in yards, of the breadth of Dog's Mead.
8. The number of minutes Farmer Dunk needs to walk one and one third times around Dog's Mead.
9. See number ten down.
10. Ten across times nine down.
12. One more than the sum of the digits in the second column down.
13. Length of tenure, in years, of Little Piggly by the Dunk family.



SEND PROBLEMS, SOLUTIONS, AND COMMENTS TO ALLAN J. GOTTLIEB, '67, THE COURANT INSTITUTE, NEW YORK UNIVERSITY, 251 MERCER ST., NEW YORK, N.Y. 10012.

F/M 3. Joe Verducci sent us the following problem, a variation of a problem suggested by Robert Bartoczinski:
N (= 2k + 1) people own a bank. What is the minimum number of different locks that must be put on a safe so that when keys to these locks are distributed to the different people, every majority contains a complete set of keys, but no minority does?

F/M 4. Bruce Calder likes to speak softly and drop a long (meter) stick:
A rigid, uniform stick one meter long is held leaning against a smooth vertical wall at a 30° angle to a smooth horizontal surface. When the stick is released, how fast will its center pass point A?



F/M 5. John Rudy's nine-year-old came home with the following problem:
(1) Choose any four different digits.
(2) Arrange them to make the largest number.
(3) Arrange them to make the smallest number.
(4) Subtract the smaller from the larger.
(5) Take the result and go back to step 2 and see what happens.
John and Joel Shwimer noticed that the procedure always converged to 7641. They ask why and whether there is a similar phenomenon for five-digit numbers.

Speed Department

SD 1. George Byrd asks a problem similar to one mentioned by Ken Thompson in his acceptance of the ACM Turning Award:
Write, in any language, a computer program that makes explicit or implicit reference only to the computer terminal device. When the program executes, its only action should be to cause a listing of itself to appear on the terminal device. A child allegedly proffered the solution to the computer scientists who were pondering the problem.

SD 2. We conclude with an offering from Doug Van Patter:

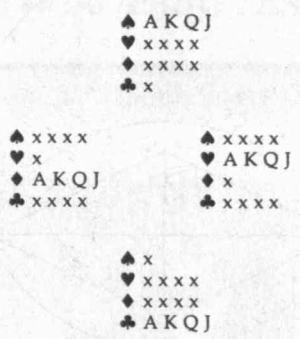
North:	East
♠ K 9 3	♠ 10 7 6
♥ 6 4 3	♥ A K Q 7
♦ A J 9 2	♦ Q 7 5
♣ Q 7 4	♣ J 10 9

In a rubber bridge game, the bidding has gone: South 1NT, North 3NT. Your partner leads the ♥10, and everyone follows to three rounds of hearts. What is your best chance at setting this game?

Solutions

OCT 1. Consider a duplicate bridge tournament in which every hand was played 20 times. One of these hands produced a strange result. At four of the tables the final contract was one club, played once from each of the four sides. At four of the other tables it was played at one diamond once from each side. At the remaining tables it was played once from each side at one heart, one spade, and one notrump. Every one of these contracts was set. Analysis of the hand proved that none of the declarers made a mistake in play. What hands were originally dealt?

Herb Manning had no trouble setting all the contracts. Indeed, they are all down two. A deal in which each player holds a 4-4-4-1 distribution, with A-K-Q-5 in the suit of the partner's singleton, would allow the defense to take eight tricks off the top, no matter what the contract. For example:



Also solved by Winslow Hartford, Robert Bart, Timothy Maloney, Thomas Chang, Matthew Fountain, Dan Sheingold, Tim Schiller, and the proposer Lawrence Kells.

OCT 2. Twenty-four cards, the 1-6 of each suit, are put face-up on the table. Two players pick up alternately, each keeping track of his pip-total. One wins by hitting *thirty-one* or forcing one's opponent to exceed 31. Does the first or second player have a sure win, and how does he play to insure it?

Several readers asserted that the first player can win by just taking the largest card available. This is refuted by 6,2; 6,2; 6,2; 6,1 and the second player wins. The clearest solution comes from the proposor, Smith D. Turner, *fdt*, who writes:
It is evident that if a player reaches 24, and there is a card of each denomination left, he wins; and with 17 he can reach 24, etc. But as one of each denomination may not be left, this plan requires refinements, as below.
First player can always win if he starts with 1, 2, or 5 and then plays to make 10, 17, 24, except:
10 loses with two of any denomination gone, unless two 2's and one 1 are gone.
17 loses with three of any denomination gone, unless three 2's and two 1's are gone.
24 loses with four of any denomination gone, unless four 2's and three 1's are gone.
While I can't prove above will insure a win, no one has produced an exception. A solution was in the magicians' journal *Sphinx*, page 294, October, 1932, but it omitted the exceptions in the above beginning with the word "unless." There are so many possible situations that a player knowing the above can, with considerable safety, risk playing second or taking other losing positions early in the game to keep a novice from catching on!

Also solved by Winslow Hartford, Allen Wiegner, Robert Bart, Thomas Chang, Matthew Fountain, John Bobbitt, and Jim Rutledge.

OCT 3. A very wise dean wishes to improve the quality of research and education at her university. She believes some of the "fault" is with the department heads, but, being wise, recognizes some of the "fault" may be with herself. For starters, she decided to relocate her office so as to *minimize* the average distance to her department heads. Where should she locate her office? (For simplicity, assume all offices are located in a plane and that the dean cannot co-reside with any department head).

Robert Bart and Harry Zaremba noticed that the dean should be at the centroid of the chairmen [this sounds like a political remark—ed.]. If there is a chairman located at the centroid, no solution is possible [since deans do not share offices with chairmen!—ed.].

OCT 4. An exploring team wants to reach a destination that is six days away. Each explorer can carry enough provisions to sustain one person for four days (and the distance an explorer travels in a day is independent of the amount of provisions he or she is carrying). What is the smallest team that permits at least one explorer to reach the destination and permits all the explorers to return home safely?

The solution depends on how you interpret the conditions. Tim Schiller found two interpretations and thus two solutions. John Bobbitt has all the explorers leave at one time for a third solution and a magnificent punch line. Mr. Schiller writes:
As stated, the obvious answer is one person if he does all of his shuttling. It would take 63 days to complete the task. If you add the requirement that the expedition take only 12 days, then the minimum number of people is 8. The following diagram shows the locations of the people (first number) and the food (second number) at the end of each day:

	Base						Goal
Day	0	1	2	3	4	5	6
1		8/24					
2	3	/1	5/15				
3		4/10		4/10			
4	3	/3	3/3	/1	2/5		
5		6/12		1/1		1/3	
6	4		3/6				1/2
7		6/12		1/3		1/1	
8	4		2/6		2/2		
9		5/12	/1	3/3			
10	4	/4	4/4				
11	4	4/4					
12	8						

Mr. Bobbit's more fanciful solution follows:
A Star Wars satellite has exploded over Russia, but the bright orange "black box" has survived. Its beacon has pinpointed it in the remote Ural Mountains. A recent snowstorm over the area has made air travel impossible for at least two weeks. But the box must be recovered. Thus, a handpicked group of 16 intrepid explorers set off to recover the black box which is six days away from the starting point. The 16 include 8 East Germans, 4 Hungarians, 2 Albanians, 1 Romanian, and a small Czechoslovakian. Because of the cold-weather equipment needed to keep warm, each of these men is able to carry only four days' supply of food. They head out in good spirits, eager to serve Mother Russia. At the end of the first day, they reach stop point 1. Each of the 16 has eaten the first day's supply of food. The next day, each of the 8 East Germans gives a packet of food to the other eight, they set up 8 caches of food for these 8 to use when they return, and they head back with the other eight packets of food. The other eight bid farewell to the East Germans and head off again with a four days' supply of food each and the comforting knowledge that there is a cache of food for each at stop point 1. The trip continues with the numbers cut in half each night. At stop point 2, the 4 Hungarians return, leaving 4 food caches for the 4 who continue on. At stop point 3, the 2 Albanians return, leaving 2 caches, and the Romanian and

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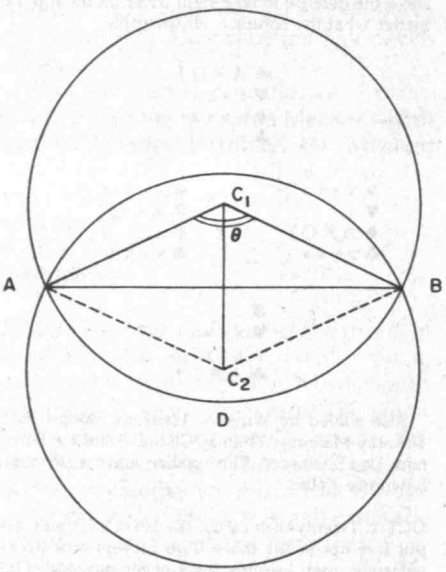
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Czech travel on to stop point 4. Arriving at stop point 4, each finishes a day's supply of food, leaving 6 uneaten. Noting the place well, the Czechoslovakian stores a packet out of reach of the wolves and bears, keeps his 4, and leaves the other packet for his Romanian comrade. The next morning the Romanian returns with his packet, and the Czech heads off on his last 2 days. The 4 days' supply will get him to the black box and back again to stop point 4. And from that point on, he knows that every day there will be another cache for a small Czech.

Also solved by Winslow Hartford, Ellen Kranzer, Norman Wickstrand, Allen Wiegner, Dennis White, Robert Bart, Matthew Fountain, Avi Ornstein, Frank Carbin, Charles Sutton, Harry Zaremba, Jim Rutledge, Gardner Perry, Michael Jung, Bill Wold, and the proposer, Yogesh Gupta.

OCT 5. Two cats are fed a single can of cat food. The food comes out of the can as a single intact cylinder, and the can is then used to cut the cylinder into two shares of food. Where should the can be positioned to generate equal shares?

The following solution is from Winslow Hartford.



Assume the two circles have unit radius. Then the area of segment ADB is $\pi/4$.

$\pi/4 = \pi \times \theta/2\pi - \sin\theta/2$

$\theta - \sin\theta = \pi/2$

$\theta = 132.34645°$.

Then C_1C_2, the distance between centers, is

$2\cos\theta/2 = 0.80795$.

The center of the cutting can is therefore 0.80795 radii from the center of the cat food.

Also solved by Ronald Raines, Robert Moeser, Mike Hennessey, Dennis White, Robert Bart, Steve Feldman, Frederic Jelen, Phelps Meaker, Timothy Maloney, Alan Berger, John Prussing, Thomas Chang, Matthew Fountain, Roger Whitman, Ken Rosato, Frank Carbin, Harry Zaremba, Jim Rutledge, Dan Sheingold, Steve Silberberg, and Raymond Gaillard.

Better Late Than Never

M/J 1. Charles Rivers [what a name for an MIT alumnus—ed.] and Michael Krashinsky remark that this problem is considerably more complicated and interesting that the published solution would lead one to believe. They each give detailed descriptions of how the contract can be made against any defense. Mr. Rivers writes:

The five-club contract can be made against *any* lead and any defense! The proposer is to be commended for a most intriguing double-dummy problem and the red herring in the form of an apparent "giveaway" lead. In order of difficulty:

1. If West leads a low heart, Declarer takes three hearts in Dummy (discarding spades) and plays ♦K and ♦A. East must ruff or Declarer makes six! East's black card return is won in Dummy and Declarer now can draw trump (♣K,♣J,♦ ruff and ♣A) and has six trump tricks to go with three hearts, one spade, and one diamond.

2. If West leads *any* minor suit card, Declarer takes ♦K,♣K (or ♣K,♦K if West leads the ♣Q), then plays ♦A:

☐ If East discards, Declarer cashes ♥A,♥K (discarding a spade), ♥ ruff, ♠A, ♦ ruff, ♣K, ♦ ruff, ♣J, ♦ ruff, and ♠A for eleven tricks.

☐ If East ruffs and returns a black card, Declarer cashes Dummy's other black winner, ruffs a diamond and runs all the trumps. Dummy is reduced to three hearts and one diamond and West is strip-squeezed into the same distribution. Now a heart lead forces an honor from West and the last diamond throws him in for another heart lead.

☐ If East ruffs and returns a heart, Declarer cashes ♣J, ruffs a diamond, and runs trumps reducing Dummy to ♠A,♥K,♥10,♦7. Now a spade is led to Dummy. East must hold at least two hearts and is thrown in with the last diamond as before.

3. If West leads a heart honor, the first eight tricks are: ♥A, ♥K (discarding a *diamond*), ♥ ruff, ♦A, ♦ ruff, ♣K, ♦ ruff, and ♠ *ducked*. West is in with the ♠K and must lead a red card which Declarer ruffs in hand. Now ♠A; ♦ ruff with Declarer's last trump, and Dummy's ♣J is the eleventh trick.

4. Finally, if West leads ♠K, Declarer *ducks*:

☐ If West shifts to heart honor (a low heart makes it easy), Declarer takes ♥A, ♥K, (discarding a *diamond*), ♣10 ruffed, ♦A,♦ ruff, ♠A (if West ruffs a low spade lead, Declarer takes the rest on a cross-ruff), ♦ ruff, ♠ conceded. If East returns a spade, it is ruff with ♣J, and ♣K is cashed. Now a diamond is led toward Declarer's ♣10, ♣A. If East returns a trump, the ♣K is taken, ♦ ruff, ♠ ruff, ♣A. And if *West* ruffs the conceded spade trick, West's red suit return allows Declarer to make the rest on a cross-ruff.

☐ If West shifts to a diamond, Declarer takes ♦K,♥A,♥K (discarding a *diamond*), then ♦A. East must ruff or Declarer will easily make 11 tricks. Declarer overruffs, then ♠A (as above, it does West no good to ruff in), ♦ ruff, ♠ conceded. With a spade return, ruff with ♣J, ♥ ruff (if declarer carelessly ruffs Dummy's ♥10 earlier, West can discard all diamonds and prevent cross-ruff), ♣K, ♦ toward the ♣A, ♣9. With a trump or heart return, the play follows the lines as above.

☐ If West shifts to the ♣Q, Declarer takes ♣K,♣J to ♣A,♣9 to East's ♣10 (if East ducks Declarer continues clubs). If East returns a major suit card, Declarer cashes Dummy's major suit winners, enters his hand with the ♦K and runs trumps, squeezing West in the red suits. If East returns a minor suit card, Declarer wins in hand, draws the last trump (if necessary), cashes ♠A and the top diamonds, ruffs a diamond, and runs trumps to squeeze West.

I apologize for the long explanation, but as I said at the start, this is an intriguing hand!

M/J 4. Greg Huber remarks that analogues of octahedrons also exist in all dimensions.

JUL 5. Phelps Meaker has responded.

A/S 4. Jim Rutledge has responded.

A/S 5. Leon Tatevossian and Michael Jung have responded.

OCT SD1. Raymond Kinsley, Richard Heldenfels, Yardley Chittick, and Jim Rutledge noticed that the correct answer is 2:46 2/13.

Proposers' Solutions to Speed Problems

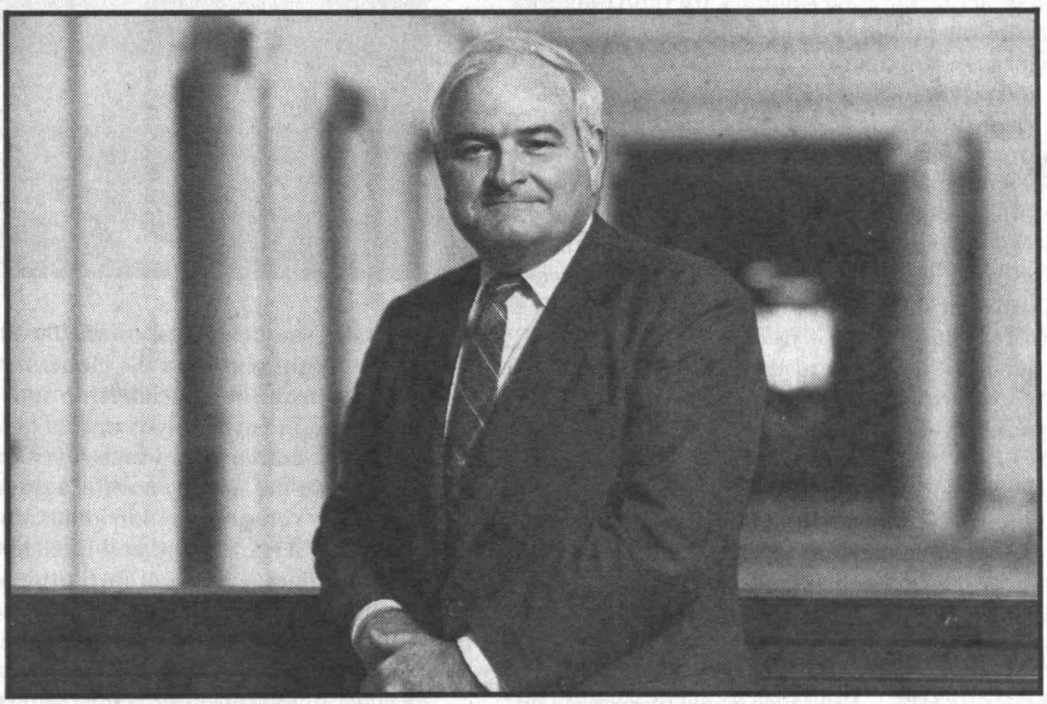
SD 1. A solution: Use the BASIC language, and write the line
10 LIST 10

SD 2. Don't cash your fourth heart! Lead a club and hope that declarer places the last heart in your partner's hand. Then it would be safe to take the diamond finesse into your hand.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

REPORT OF THE PRESIDENT

FOR THE ACADEMIC YEAR 1984-85



PAUL E. GRAY, PRESIDENT OF MIT

The genius of MIT is that on every hand its people are caught up in the idea of the future. They may . . .

PHOTO: JIM HARRISON

be guided by tradition. They may be inspired by history. But they are driven by excitement about the future — what will be, what may be, what can be.

As I remarked in this report a year ago, the spirit of inventing the future was an essential element in the organizing concept of MIT put forth 125 years ago by our founder, William Barton Rogers, a spirit we will celebrate in our quasquicentennial observances early in 1986. It is a source of pride for all connected with MIT that this university and its people have for so long kept faith with that spirit.

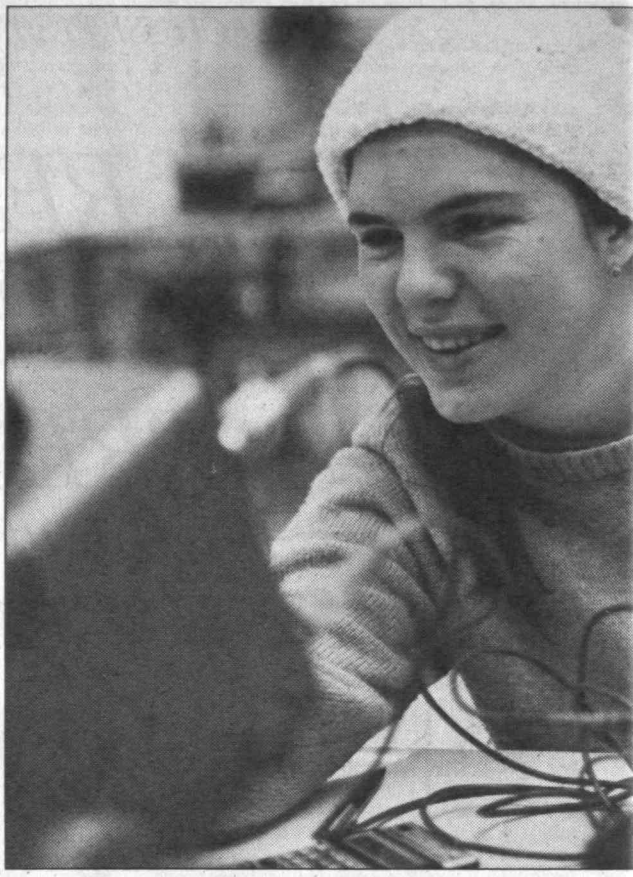
By a coincidence of calendar, this annual report is written at about the time students are returning for the start of the fall term. They bring with them all the eagerness, anticipation, and hope of a new generation. And they bring talent. Looking at them, we cannot help but recognize that these are the faces of the future, and that MIT has a pact with that future.

Concern with the future has invested MIT with international stature. We have evidence at every hand that MIT enjoys a position in the first rank of the great research universities of the world. This is true if you consider formal appraisals of the quality of academic institutions or if you rely on reports of a more personal, impressionistic, or anecdotal character. The exceptional stature of this remarkable university is evident to all.

This happy state has developed in the decades since the Second World War — decades that have marked both the beginning of MIT's involvement with sponsored research on a large scale and the remarkable flowering of several key scientific disciplines where MIT people have demonstrated special leadership.

They have been marked, too, by the cardinal influence that MIT people have come to exercise on higher education throughout the nation and the world. It is an influence felt in the shape and substance of curricula, of textbooks, of the educational encounter itself. Many of the educational programs in which we pioneered — such as the project laboratories and the Undergraduate Research Opportunities Program — set standards that are followed at many of our sister colleges and universities. And newer programs, such as Project Athena, hold similar if not greater potential for affecting the ways in which we learn and teach.

Beyond the activities in our own classrooms and laboratories, perhaps MIT's most profound influence on education and research rests with the 4,000



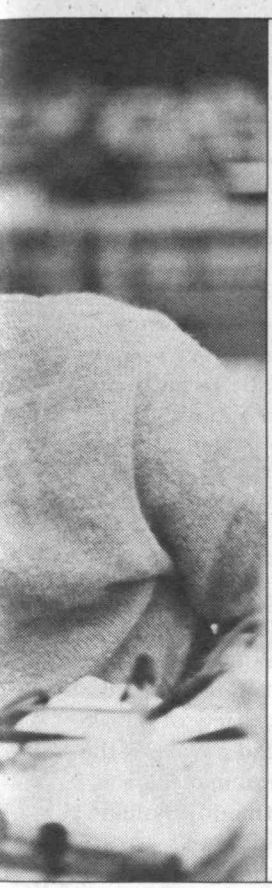
graduates who now serve on the faculties of colleges and universities around the globe.

While institutional leadership such as ours does not submit to easy analysis or to a quick listing of the several qualities on which it critically depends, it is clear that the *sine qua non* for academic leadership is a faculty comprising individuals who possess uncommon energy, insight, and intellectual capacity, and who share a vision of institutional mission and potential, a vision of the future.

By definition, such faculties can never be static. Faculties that lead are those that are continuously engaged in processes of change and renewal. The same can be said for the scholarly disciplines that underlie MIT's organizational structure. Individuals, acting in pursuit of the challenging ideas and questions of their fields, break new intellectual ground, and in so doing, contribute both to the common store of knowledge and to our capacity to educate our students.

One important element in sustaining faculty leadership may be found in the unending process of renewal that results inevitably from the arrival each year of women and men at the beginnings of their academic careers. These are the agents who bring new and different perspectives to MIT. They enrich the intellectual fabric of the place, whether their stay

PHOTO: STEPHEN G. SISAK, '87



There were 2,211 women students at the Institute in 1984-85, compared with 2,066 in 1983-84.

is of a few years' duration or whether it is permanent. In either case, it is these people who are of critical importance in sustaining MIT's position of leadership in the future.

These faculty colleagues — and our ability to provide the setting and conditions which foster excellence and achievement — hold the key to MIT's future. Let me give substance to these assertions by citing specific examples from the ranks of those who have joined the faculty in recent years.

In the Department of Urban Studies and Planning, Assistant Professor Lynne B. Sagalyn is in the second year of a two-year appointment to a career development professorship endowed by the Class of 1922. Professor Sagalyn, trained in urban economics and planning, has conducted research that has won national attention in an area of keen interest to all Americans — the cost of buying and the methods of financing housing, particularly for minorities and those of modest means. More recently, she has extended her studies to the analysis of the rejuvenation of downtown areas undertaken with varying combinations of public and private finance. She has found teaching far more stimulating than her original forays into this area as a doctoral student had led her to expect. Her fresh introduction of financial aspects of housing and development into the department's curriculum, together with her spirited teaching manner, have gained special recognition for the department and have attracted students from a variety of disciplines.

Dr. Philip S. Khoury, Associate Professor of History in the Department of Humanities, also a recipient of a Class of 1922 Career Development Professorship, has brought to MIT special distinction for rigorous scholarship in the study and teaching of the political and social histories of the peoples and the nations in the Middle East. His books and articles have earned wide praise, particularly for the new understandings he has been able to present in comparative urban history in the Middle East and in comparative nationalist movements in that region. Students — and faculty from his own and other departments — fill his classes on contemporary Middle Eastern affairs, seeking insights gleaned from scholarship and from personal heritage on the tragic and seemingly interminable conflict that rages in that part of the world.

In the Department of Chemical Engineering, where he held the Atlantic Richfield Career Development Professorship until last December, Assistant Professor T. Alan Hatton has proven to be an important asset as teacher, research scientist, and faculty resident in an undergraduate house. Professor and Mrs. Hatton, who live in MacGregor House with their two young sons, regard their interaction with undergraduates as emblematic of what we are all about here. A recipient of the Everett Moore Baker Award for Excellence in Undergraduate Teaching, Professor Hatton takes obvious pleasure in working with undergraduates. He is in charge of a new undergraduate process laboratory, which forms an important part of new educational initiatives underway in his department. His research interests on continuous bioseparation processes relate to assuring an industrial future for genetic engineering.

In the Department of Biology, Assistant Professor Barbara Jean Meyer, a recent recipient of the Whitehead Institute Career Development Assistant Professorship Award, is pursuing an exciting

line of research in molecular and developmental biology. Her basic interests focus on trying to understand how genetically derived programs of development are implemented in an organism as a single cell matures into an adult. These interests have been channeled into an investigation of sex determination in nematodes, simple microscopic soil-dwelling worms that exist either as males or as self-fertilizing hermaphrodites. Professor Meyer's particular concern is the identification of the genetic and biochemical signals that are responsible for transmitting information carried on the sex-determining chromosomes to other genes that are responsible for bringing about either the male mode or the hermaphrodite mode of development. Professor Meyer is attracted to an academic career since it allows her the freedom to pursue basic research unfettered by the requirement of producing marketable items. She is an energetic and effective teacher who takes seriously the need to provide her students with the advice, criticism, and inspiration that mark a good mentor.

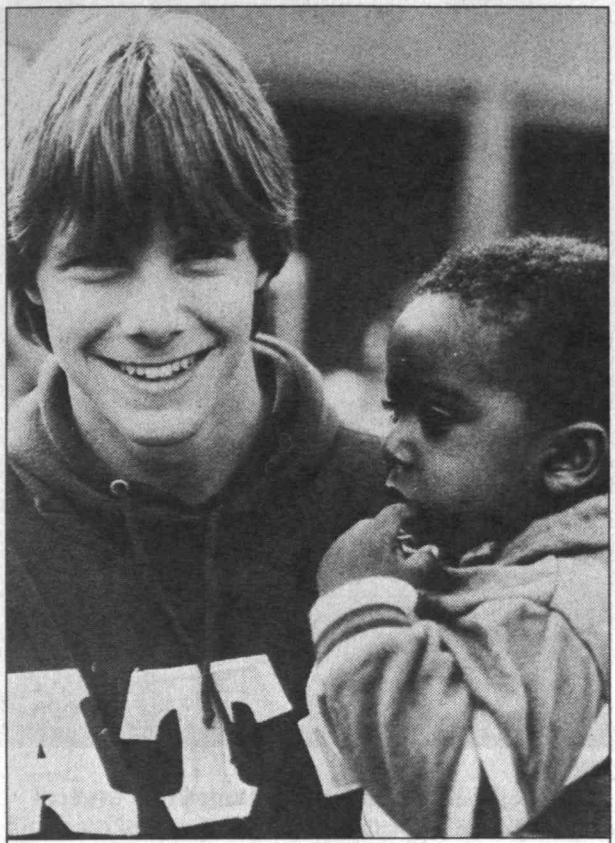
The Department of Electrical Engineering and Computer Science is currently one of the bases for a young scientist with an extraordinary range of interests and talents — Dr. Raphael C. Lee, a surgeon and an electrical engineer. His scientific interests relate to how physical forces in developing skeletal and connective tissues are translated into biochemical events, and, toward that end, he pursues careers in both engineering and medicine. On MIT's side of the Charles River, he is Karl Van Tassel Career Development Assistant Professor of Electrical Engineering and Biomedical Engineering and is a faculty member in the Harvard-MIT Division of Health Sciences and Technology. On the other side of the Charles he is Assistant Professor of Plastic Surgery at Harvard Medical School and a member of the surgical staffs at Children's Hospital and Brigham and Women's Hospital. He also holds appointments at several other Boston area hospitals. In addition to his research, Professor Lee teaches electromagnetic theory and muscle physiology in our EECS department, the anatomy of hand and facial nerves in HST, and supervises a variety of thesis research projects by both undergraduate and graduate students.

Associate Professor Randall Davis is now a tenured faculty member in the Sloan School of Management where he is helping to mold the School's innovative programs in management information systems. From 1979 to 1981, when he was a newly appointed assistant professor in the Department of Electrical Engineering and Computer Science, he held an Esther and Harold Edgerton Career Development Professorship. His particular interest focuses on knowledge-based systems, a subfield of artificial intelligence. These systems are computer programs that abstract and systematize the specialized knowledge of recognized experts in a given field, enabling the systems to perform as well as experts, using much the same sort of reasoning. Management scientists look forward eagerly to the development of a variety of knowledge-based systems that will extend markedly the skill and effectiveness of industrial managers employing computer-based information systems.

These brief profiles provide some sense of the stimulating, demanding activities of our faculty. Their interests and talents are far-ranging and compelling. While their fields are disparate, each of these faculty colleagues has one thing in common: significant and timely career development support including, for each of them, a career development chair. This financial support has made a critical difference — providing not only the freedom and funds to pursue research interests, but also the encouragement and vote of confidence at timely points in their academic careers.

We have an obligation to provide the conditions necessary to stimulate and support this kind of creativity in research and teaching. Salaries are, of course, an important factor in our ability to attract and keep the best teachers and scholars. In terms of basic salary, the Institute is competitive, school by school, with its peer institutions, but we still must ask most of our faculty to raise a portion of their own academic–year salaries through research funding. This includes those who are at the beginnings of their careers, and may not yet be well established in their research programs.

At present about 18 percent of our academic-year faculty salaries are charged to sponsored research grants or contracts. (In the Schools of Science and Engineering this fraction is 24 percent.) The practice of charging academic–year salaries to sponsored re-



Looking at our students, we cannot help but recognize that these are the faces of the future and that MIT has a pact with that future.

search funds began at MIT in the 1950s; it was one of the ways the Institute leveraged the rapidly growing federal investment in research to increase its size at a time of very strong demand. But there is a cloud over this general practice at present and it holds special portent for newly appointed faculty and for our ability to compete with better endowed institutions.

The practice of paying a part of faculty salaries from research grants and contracts works to the disadvantage of our faculty in the competition for research support. By requiring that research pay a part of the cost of faculty salaries, we put the cost of doing research higher than comparable costs for research performed at those universities, such as the large, publicly supported institutions, which pay all academic-year faculty salaries out of general funds. In any case, MIT's practice places heavy demands upon members of the faculty, including those who are just beginning careers as independent investigators, to generate a steady stream of grants and contracts to support not only the students, technicians, and postdoctoral fellows who are engaged in their research, but also a portion of their own salary and benefits. It strains loyalty to the institution and to undergraduate education.

Basic salary, which is compensation for a faculty member during the September-to-May academic year, is not the only dimension in which we must compete. Research, scholarly activity, and preparation for teaching, particularly the development of new educational materials, continue during the summer. For all, summer is a time when energies can be concentrated, without the regular, repetitive schedule characteristic of the academic year.

We encourage faculty members to be employed by MIT during the summer and to earn additional compensation of up to two months of academic-year basic salary. For most, summer employment is an essential part of their total personal income needs. This tends to be especially true for those just starting careers.

But again, in order to be paid for summer activity, a faculty member must be engaged in activities that have funding available to support summer salaries and benefits. Such activities include teaching in the summer session, working on curriculum development projects, and, primarily, conducting sponsored research. As one might guess, summer support tends to be concentrated in the Schools of Engineering and Science, which have a great many sponsored research programs, and among the more senior faculty. Junior faculty who are not yet experienced in developing research support are much more likely to seek essential summer employment outside of MIT. While they usually pursue outside work that is supportive of personal growth, these individuals are not active members of this community during the summer, and MIT is diminished by their absence.

Beyond salary support, there are other things a flagship institution should do to give newly appointed faculty members the start they need. We should be in a much better position to help new faculty members, particularly those beginning an academic career following graduate or post-doctoral study, begin their research programs. The largest share of the costs of research and scholarly activity will continue to be provided by federal and indus-

PHOTO: BRADLEY FILES

trial sponsors, as at present. However, the person striking out for the first time as an independent investigator needs some assistance in developing his or her interests to the point where an outside agency is likely to take an interest in the work. Such start-up funds are usually required to equip a laboratory and to support a graduate student colleague for a year or two. The men and women who are members of the MIT faculty are remarkably effective in generating research support on the basis of the quality, innovativeness, and impact of their work. Nevertheless, new junior colleagues remain greatly in need of institutional assistance in getting started.

For many years we have relied on two endowed research funds for this purpose. The Alfred P. Sloan Fund for Basic Research and the Godfrey L. Cabot Solar Energy Fund together generate just over $2 million per year, which is allocated by a small committee chaired by the Provost. Several of the persons whose profiles appear in the previous section of this report have benefited from these internally generated and controlled seed funds. Important as they are, these funds are limited in two respects. First, the annual income they generate is just 1 percent of the total annual expenditure for sponsored research on this campus; these funds are simply inadequate to the task at hand. Second, they are constrained in their application to work in engineering, the physical sciences, and in nuclear physics. Consequently, important areas of activity, such as the humanities and social sciences, architecture, and management are without institutional sources of seed funds.

Another element of faculty support that relates directly to leadership in academic affairs is our ability to support new educational developments. The development of a new subject, the revision of a departmental course of instruction, or the development of a new text or other form of instruction, all require major investments of thought and energy. They are not activities that are easily undertaken as adjuncts to a normal commitment to teaching and research activities. Such investments in our future as an educational institution are greatly aided by releasing a faculty member from some portion of his or her normal duties for a term or two or by supporting that person during the summer so that time can be spent on educational development. Of course, this requires some source of institutional funds, analogues in many respects to seed funds for research.



Each of these conditions for leadership — necessary to ensure a position in the first rank of the great research universities — places demands on the resources of the Institute. They are demands that cannot be met by increasing tuition charges or by expanding the research programs. If we are to respond to these needs regularly and steadily, we must garner substantial additions to the Institute's invested capital base: our endowment. These additions may take many forms:

- Unrestricted endowment, the income from which can be used to support any of these needs, but which is essential if we are to continue our efforts to support a much larger fraction of basic academic-year faculty salaries with MIT funds.
- Endowed professorships, which provide the holder both with important recognition and with secure funding for salary and for initiatives related to the chairholder's educational or research interests.
- Endowed funds, which can be used to seed new research initiatives or to support new educational developments. These funds provide an essential element of institutional flexibility, and their leverage is very great.

Such support is essential if we are to attract and retain new faculty members of the first rank, the individuals who ultimately will sustain into the future this university's leadership in teaching and research.

PHOTO: JIM HARRISON



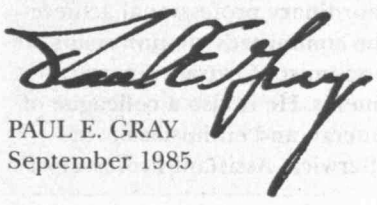
Beyond activities in our own classrooms and laboratories, perhaps MIT's most profound influence on education and research rests with the 4,000 graduates who now serve on the faculties of colleges and universities around the world.

Perhaps no one understands the need, and the conditions, for institutional renewal more than our much-loved former president and chairman of the Corporation, James R. Killian, Jr. In over six decades of association with this university, he has had an extraordinary influence on the shaping of MIT's character and its devotion to excellence in all things.

This spring, the MIT Press published Dr. Killian's book, *The Education of a College President: A Memoir*. In a reflective chapter at the end of the book, he gives warmth and depth to this university's unending need for renewal through new generations of faculty:

> My hope of progress comes naturally from my having lived so long in the regenerative sanctuary of a research university deeply committed to the pursuit of the first-rate. Along with this circumstance has come the sustained invigoration provided postmeridian by association with a singular fellowship of young men and women working in a contagious atmosphere of excellence, discovery and high spirits.

I look to all within the MIT family — teachers, students, staff, alumni — to join together to sustain this "contagious atmosphere." This is our heritage and our future.



PAUL E. GRAY
September 1985

In Special Recognition

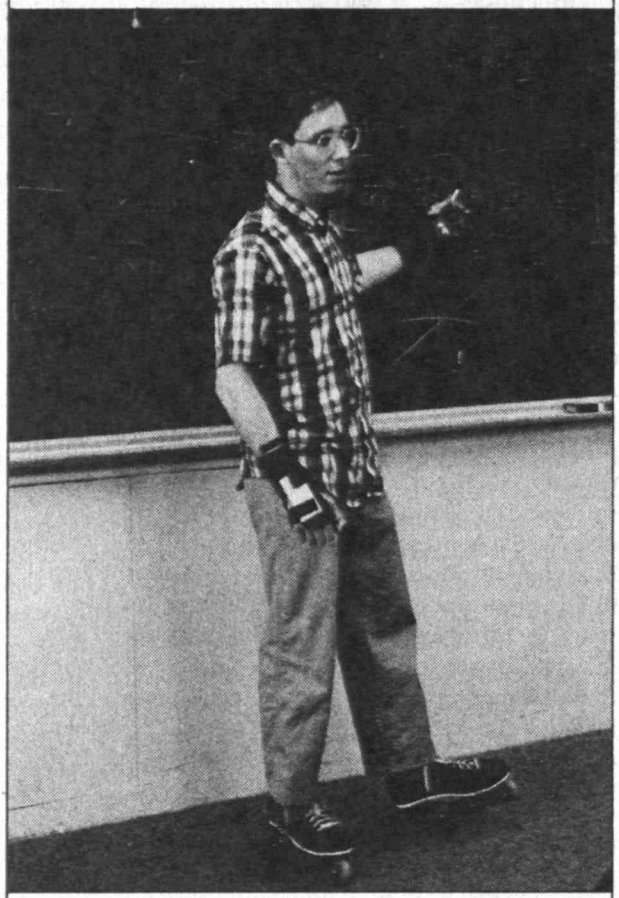
Every year there are occasions which remind us of the special character of the many individuals who collectively mold the character of MIT. This past year several key leadership roles at the Institute changed, and those transitions were occasion for special recognition.

In the fall of 1984 Francis E. Low announced his intention to step down as Provost when the 1984-85 academic year ended in order to return to teaching and research. During his tenure as Provost, Professor Low led an Institute-wide academic planning process that will give guidance to the university, its Schools, and its departments in the management and allocation of its resources. In addition, he served as MIT's principal representative in shaping the MIT affiliation with the new Whitehead Institute for Biomedical Research. Above all, Francis Low has consistently displayed a concern for the intellectual vitality of the Institute and for the people who make up the Institute community. As my closest colleague for five years, he brought sound judgment, a balanced and incisive perspective, a gentle humor, and high energy to the affairs of the Institute. In recognition of his leadership, accomplishment and service as scholar, scientist, and administrator, he was named an Institute Professor in the spring of 1985.

John M. Deutch, Arthur C. Cope Professor of Chemistry, who has served as Dean of the School of Science since 1982, was appointed Provost of MIT effective July 1, 1985. Professor Deutch brings to his post a background in a broad range of intellectual fields, wide experience in academic administration, extensive involvement in national science policy, and a dedication to excellence in teaching and research. A member of the MIT faculty since 1970, Professor Deutch is a former Under Secretary of the US Department of Energy. He is a recognized authority in nonequilibrium statistical mechanics, the structure of fluids, dielectric and magnetic relaxation, light scattering and polymer physical chemistry. Professor Deutch's commitment to the mission and values of MIT, together with his enthusiasm for exploring new horizons, will contribute enormously to his effectiveness as Provost of MIT.

Gene M. Brown, Head of the Department of Biology, was appointed Dean of the School of Science effective July 1, 1985. A noted enzymologist, Profes-

As students return for the start of the fall term, they bring with them all of the eagerness, anticipation, and hope of a new generation.



In full roller skating gear, Jamie Keller, '87, gives an ESG math tutoring session.

sor Brown has headed the Department of Biology since 1977.

The special character of MIT is also seen each year in the achievements and honors of its faculty. While it is not possible to take note of every such distinction, there are some highlights which deserve mention.

In the late winter, the National Academy of Engineering elected six members of the MIT faculty. New MIT members are: Allan F. Henry, Professor of Nuclear Engineering; Erich P. Ippen, Professor of Electrical Engineering; Ronald M. Latanision, Shell Distinguished Professor of Materials Science; the late Philip M. Morse, Professor of Physics, Emeritus; Claude E. Shannon, Donner Professor of Science and Professor of Electrical Engineering and Mathematics, Emeritus; and Sheila E. Widnall, Professor of Aeronautics and Astronautics.

During the spring, six members of the MIT faculty were also elected to the National Academy of Sciences. Those new MIT members are: B. Clark Burchfiel, Schlumberger Professor of Geology; Mildred S. Dresselhaus, Abby Rockefeller Mauzé Professor of Electrical Engineering and Physics; Victor W. Guillemin, Professor of Mathematics; Professor Ippen; K. Barry Sharpless, Professor of Chemistry; and Robert A. Weinberg, Professor of Biology.

Five members of the MIT faculty were among those elected as Fellows of the American Academy of Arts and Sciences at its meeting in May. New MIT members are: David Botstein, Professor of Genetics; Mary Lou Pardue, Professor of Biology; W. Gilbert Strang, Professor of Mathematics; Christopher T. Walsh, Professor of Chemistry and Biology and Uncas and Helen Whitaker Professor in the Whitaker College; and Daniel I.C. Wang, Professor of Chemical and Biochemical Engineering.

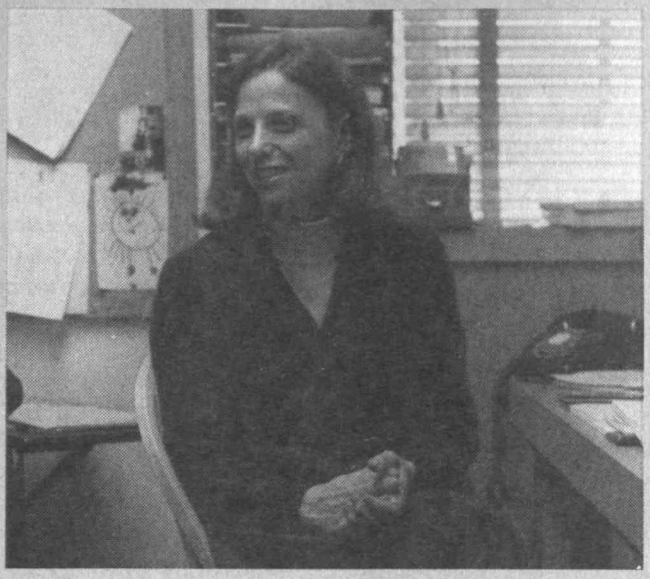
In February three members of the faculty were presented the National Medal of Science. Those honored by this recognition are: Bruno B. Rossi, Professor of Physics, Emeritus; Isadore M. Singer, John D. MacArthur Professor of Mathematics; and the late John G. Trump, Professor of Electrical Engineering, Emeritus.

The John D. and Catherine T. MacArthur Foundation awarded a MacArthur Prize Fellowship to Alar Toomre, Professor of Applied Mathematics. Professor Toomre, an applied mathematician and theoretical physicist, was awarded the prize for his work as an astronomer and his work in the dynamics of galaxies.

Within the Institute, Franco Modigliani, Institute Professor and Professor of Economics and Finance in the Sloan School of Management and the Department of Economics, was selected by his colleagues to be the 1985-86 recipient of the James R. Killian, Jr., Faculty Achievement Award. The Killian Award, established in 1971 as a tribute to MIT's 10th president, recognizes extraordinary professional achievements and service. The committee's citation reads, in part, "Franco is an economist of extraordinary professional accomplishments. He is also a colleague of exceptional insight, energy, and enthusiasm. . . ."

In May, Robert C. Berwick, Assistant Professor of

PHOTOS: HOLLY SWEET, PEGGY KUTCHER



THE research of Professor Lynne B. Sagalyn, Ph.D.'80, has ranged from exclusive suburban developments to disadvantaged inner-city neighborhoods to revitalized downtown shopping areas. Her focus has been to understand change and the role public policy plays in shaping urban development.

Professor Sagalyn is Class of 1922 Career Development Assistant Professor in the Department of Urban Studies and Planning, where she has been a faculty member since receiving the doctorate.

"You could say I'm a product of the late 1960s," she says. "When I was an undergraduate, war, prejudice, justice, and poverty were burning campus issues. I was debating between graduate study in art history or in urban planning. The social commitment of the times made the choice a clear one. . . ."

After earning degrees from Cornell and Rutgers University, she became in 1971 a research associate at Rutgers' Center for Urban Policy Research. In that post, she conducted one of the earliest analytical studies of the impact that zoning restrictions have on housing costs in suburbia, and her findings gained wide attention.

When Professor Sagalyn decided to pursue doctoral studies at MIT in urban studies and planning, her research centered on housing finance.

"There had been shifts in the real costs of housing, concern over affordability of homeownership, and shock to the traditional system of housing finance," she says. "Public policy was in flux and pressures for reform were strong. Home buyers were confronted with both increasing costs and complexity in mortgage instruments.

"There was (also) growing awareness about 'red lining'—financial institutions delineating specific parts of inner cities where they would not make home mortgage loans. Redlined areas were usually disadvantaged neighborhoods populated by blacks and other minorities, and there was vigorous debate over what to do."

Despite loan refusals, houses in neighborhoods undergoing racial change were bought and sold. In fact, during post-war decades, homeownership among non-whites increased. Houses once occupied by whites were acquired by blacks through real estate speculators. Installment contracts were the means most commonly used, and Professor Sagalyn's research looked at the dynamics of this market.

"About all that was known about these transactions was anecdotal," she recalls. "Installment sales are private contracts, rarely recorded because, typically, title does not change hands until the purchase price has been paid in full. The seller retains ownership and collects installments from a purchaser. In many states, an installment buyer has few rights as an owner and little protection as a renter. I was into a research topic with no systematic data base and no strong case history literature."

As it turned out, civil rights activism provided a source. In the late 1960s, a Chicago law firm brought a class-action civil rights suit against a group of real estate speculators on behalf of black home buyers and, in the process, amassed case histories on installment sales contracts.

"I spent several months in the firm's deep-storage rooms drawing out data to document this alternative housing finance market," Professor Sagalyn recalls. "It was exciting. I felt I was working on something of historical importance which was also at the center of a contemporary housing problem."

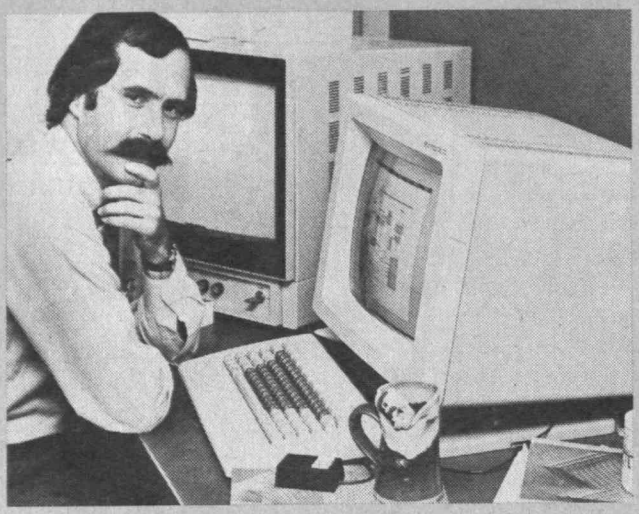
Her thesis drew the attention of urban planners because of the new light she shed on an important mechanism in neighborhood racial change.

More recently, Professor Sagalyn's research has shifted to downtown redevelopment and changing relations between city governments and private developers. She and Professor Bernard Frieden have collaborated on a study (now being expanded into a book) of downtown retail centers such as Boston's Faneuil Hall, and San Diego's Horton Plaza.

"The effort to document and write case studies has been important to understanding how complicated and innovative these projects are," she says.

The key, they say, has been changing relations between public and private sectors. City governments have developed entrepreneurial styles, sharing decisions with private developers and substituting negotiation for confrontation, to bring about projects that draw people back to cities.

An important part of Professor Sagalyn's growing academic life at MIT has been teaching. Students and colleagues rate her an excellent teacher. Moreover, she has designed new subjects, including one in real estate finance and another in downtown redevelopment, the latter taught with Professor Frieden.



SOME people want to know everything about something.

Other people want to know something about everything.

And then there are those people in the world of artificial intelligence like Professor Randall Davis, who develop "expert systems."

"When you work on an expert system for a particular field, you must learn everything you can about that field," Professor Davis says. "I find myself wanting to know everything about everything."

Professor Davis is associate professor of management science at the Sloan School of Management and a member of the Artificial Intelligence Laboratory. In both capacities, he is concerned with developing and applying expert systems—computer programs that are crammed with knowledge about a field and with the skills of logic and reason to manipulate that knowledge.

At the Sloan School, Professor Davis teaches the principles of expert systems as part of the school's recently expanded activities in management information systems (MIS). For more than a decade MIS has been revolutionizing the way managers do their work, and the addition of expert systems is expected to make MIS an even richer tool.

At the AI Lab, Professor Davis is principal investigator of the Hardware Troubleshooting Group, composed of computer scientists who are trying to formulate a theory of what it means to "understand how something works." They use as their experimental model the problems an engineer encounters when he or she must diagnose and repair a faulty computer; hence, the group's title.

Professor Davis is a relative newcomer to management science. Though only 36, however, he has been a part of research on expert systems since the field began opening up more than a decade ago.

His original ambition was to be a physicist. But within six months of entering Stanford University as a physics graduate student, Professor Davis had dropped nuclear physics and embraced AI as his major. By the following fall, he was a research assistant in the Stanford AI Lab. He subsequently joined the Heuristic Programming Project that developed MYCIN, a computer-based expert consultant for physicians in infectious diseases. His seminal contribution was the TEIRESIAS program, a system for knowledge acquisition that allowed a physician to "educate" an expert system in much the same way that he or she would educate medical students.

While working on MYCIN, Professor Davis entertained ideas of becoming a physician himself, and in 1975 he was offered admission to the Harvard Medical School. He elected, instead, to complete his Ph.D. in artificial intelligence. When HMS offered him admission for a second time the following year, he opted for a career commitment to AI.

Stanford and MIT are and always have been two of the best AI research centers in the nation. So it was not surprising in 1978, when Professor Davis' postdoctoral appointment came to an end at Stanford, that he was offered a post as assistant professor in the MIT Department of Electrical Engineering and Computer Science and research staff member in the AI Lab. In 1979-81 he held an Esther and Harold Edgerton Career Development Assistant Professorship and was promoted to associate professor in 1983.

In 1984 he was invited to join a group at the Sloan School which was then in the process of expanding the school's research and teaching in management information systems.

At the AI Lab, Professor Davis' research focuses on expert systems that work from descriptions of structure and function and are capable of reasoning from "first principles." The concept of reasoning from first principles can be grasped by comparing two kinds of reasoning we all see in experienced engineers as they contemplate why an electronic circuit failed.

When they can, veterans think their way through the problem by drawing on accumulated experience, reasoning from similar situations they have encountered. When this fails, perhaps because the problem is novel, the expert will fall back on "first principles," i.e., relying on theory and schematics, reasoning from descriptions and behavior.

Professor Davis has lectured throughout the U.S. and abroad. In November, 1985 he was one of four computer scientists in a symposium via a satellite hookup organized by Texas Instruments, Inc., and viewed by more than 34,000 people working in companies, universities, and laboratories in the United States and Canada. What's more, he is well regarded by many colleagues for his ability to write about his work in clear and plain English. It's an ability he attributes, in part, to a style of thinking that is particularly suited for work on knowledge-based expert systems.

"I've always searched for the essence of things," he says. "I think you can't really understand something until you've made it understandable to others. You do that by simplifying, getting to the core of it."

PHOTO: CALVIN CAMPBELL

Computer Science and Engineering, was named the 1985 recipient of the Harold E. Edgerton Faculty Achievement Award. The Award recognizes young faculty members for outstanding achievements in research, scholarship, and teaching. A computational linguist, Professor Berwick is developing computational models of language acquisition and processing, drawing on the work of modern linguists in explaining how people acquire language.

Several changes in senior posts in the academic administration were announced this past year. In the spring the Provost-designate, John M. Deutch, announced plans to reorganize the Office of the Provost in order to implement a major new initiative for the improvement of undergraduate education at the Institute. The reorganization includes the appointment of Professor Samuel Jay Keyser, who has served as Head of the Department of Linguistics and Philosophy and Director of the Center for Cognitive Science, to the post of Associate Provost for Educational Programs and Policy. Professor Margaret L. A. MacVicar, Cecil and Ida Green Professor of Education, Professor of Physical Science and Director of the Undergraduate Research Opportunities Program, has been appointed to the newly created post of Dean for Undergraduate Education.

Statistics for the Year

The following paragraphs report briefly on various aspects of the Institute's activities and operations during 1984-85.

Registration

In 1984-85, student enrollment was 9,626, compared with 9,577 in 1983-84. This total comprised 4,536 undergraduates (compared with 4,602 the previous year), and 5,090 graduate students (compared with 4,975 the previous year). Graduate students who entered MIT last year held degrees from 386 colleges and universities, American and foreign. The international student population was 2,145, representing 13 percent of the undergraduate and 31 percent of the graduate population. These students were citizens of 97 countries.

Degrees awarded by the Institute in 1984-85 included 1,131 bachelor's degrees, 1,045 master's degrees, 56 engineer's degrees, 447 doctoral degrees — a total of 2,679.



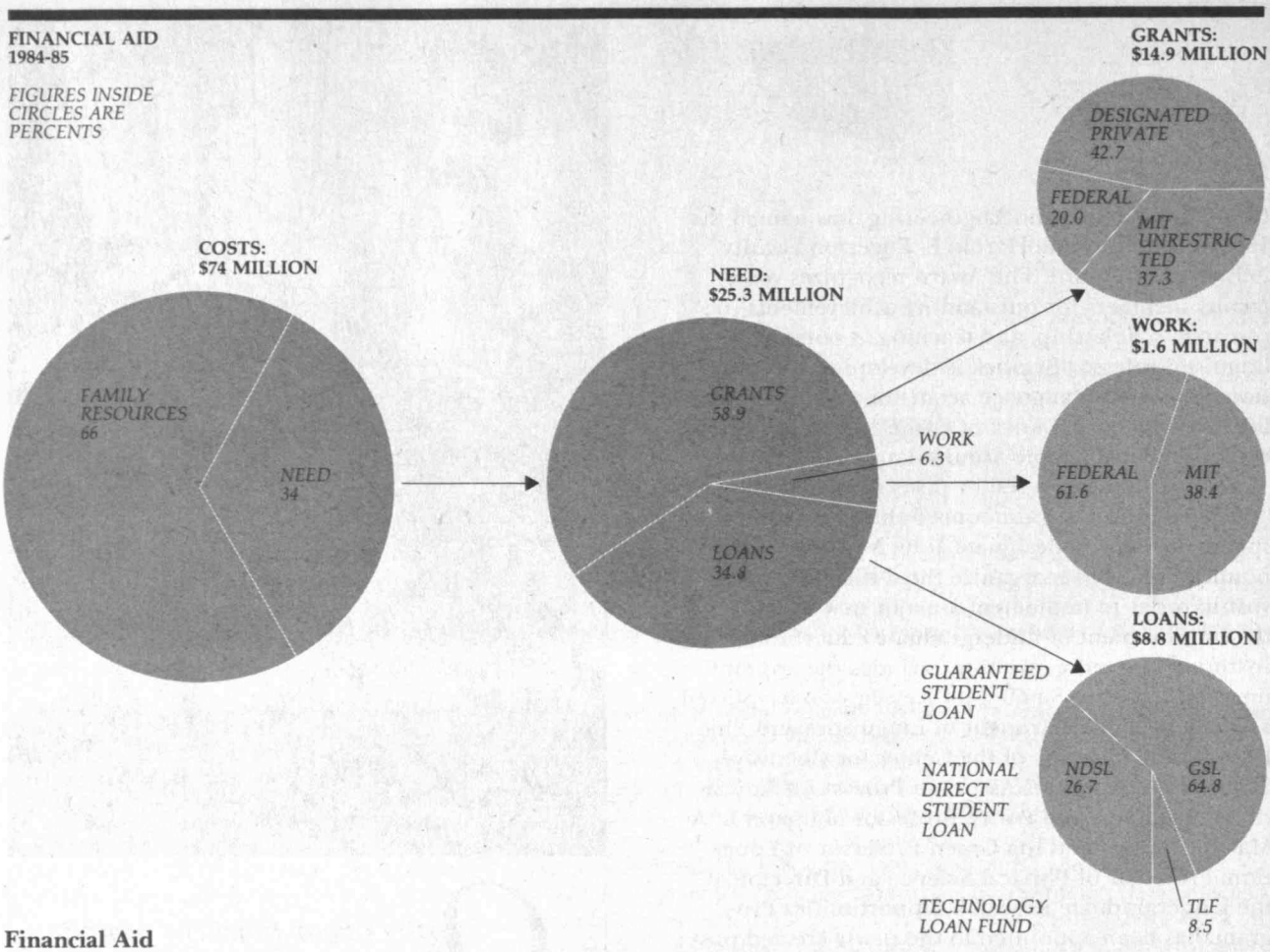
PHOTO: CHRIS MAYNARD

One career field on which the sun certainly shone was architecture. As many as half a dozen firms came recruiting—and salaries were up as much as 10 percent from the previous year.

In 1984-85, there were 2,211 women students (1,157 undergraduate and 1,054 graduate) at the Institute, compared with 2,066 (1,090 undergraduate and 976 graduate) in 1983-84. In September 1984, 309 first-year women entered MIT, representing 29 percent of the entering class.

In 1984-85, there were 1,189 minority* students (1,021 undergraduate and 168 graduate) at the Institute, compared with 1,107 (914 undergraduate and 193 graduate) in 1983-84. The first-year class entering in September 1984 included 289 minority students, representing 27 percent of the class.

*Minority students include 315 Blacks (non-Hispanic), 19 Native Americans, 200 Hispanics, and 655 Asian Americans.



Financial Aid

Financial aid policy affects both the composition of the student body and the finances of MIT. At the graduate level, financial aid is awarded primarily on the basis of academic merit, and at the undergraduate level, on the basis of need. In either case, the availability of aid is often a major factor in a student's decision to attend MIT or another institution.

The amount of financial aid for which an undergraduate is eligible is determined by a family's financial situation. Using information provided by parents to the College Scholarship Service, MIT establishes dollar amounts expected as the parents' and student's contribution. In addition, all aid recipients are expected to meet an equal share of their need through a loan and/or part-time job during the school term. This "self-help" component is set at a predetermined level each year. The remaining need is then met by a scholarship.

Financial aid for graduate students is in large part provided by individual departments and the amount available varies significantly among disciplines. Financial support includes fellowships, traineeships, teaching and research assistantships, and loans; some forms of support do take need into account.

Scholarships and fellowships totaled $29.4 million for fiscal 1985, an increase of 13 percent over the 1984 total of $26 million. Grants and loans to 2,461 undergraduates (54 percent of those enrolled) accounted for $17,948,000 of that total.

Undergraduates took out loans totaling $3,085,000 from funds administered by MIT, an increase of 28 percent over fiscal 1984. They borrowed an additional $5,719,000 from state-administered Guaranteed Student Loan Funds and other outside sources. (The median debt accumulated by members of the Class of 1985 after four years at MIT was $10,000.) Graduate students obtained loans totaling $1,622,000 from MIT and an additional $3,390,000 from outside sources.

Scholarships absorbed $8.2 million of MIT's unrestricted funds for fiscal 1985, the same as in 1984 and an increase of 30 percent over fiscal 1983. Three-quarters of that total went to undergraduates. The need for unrestricted funds continues because federal and other sources of scholarships have not kept pace with the technology-driven expense of an MIT education and because the self-help requirements for needy students have been raised at a slower rate than tuition. The Institute has limited the self-help requirement so that students are not burdened by excessive term-time employment or excessive debt after graduation.

DIAGRAM: OMNIGRAPHICS



PROFESSOR Barbara Jean Meyer, a molecular and developmental biologist, heads a research group of postdoctoral fellows and graduate students that focuses on the genus of nematodes called *Caenorhabditis elegans*.

This soil-dwelling nematode, a microscopic worm composed of only a thousand or so cells when fully matured, occurs as males and as self-fertile hermaphrodites. The major genetic difference between the two sexes is that males possess only a single X chromosome, whereas hermaphrodites posses two X chromosomes.

The question of how this organism or any organism determines and implements the correct pathway of sexual differentiation is a fundamental yet complex problem in developmental biology.

One aim of Professor Meyer's research is to trace and identify, step by step, the chain of genetic and biochemical signals that transmit information concerning the number of chromosomes in the young organism to the genes that then bring about the proper development of a male or of an hermaphrodite.

A second aim is to understand the mechanism of "dosage compensation." Dosage refers to the number of sex chromosomes present (one in males and two in hermaphrodites).

"Because sexual differentiation is determined by chromosomal composition, it is often necessary to impose a further mechanism to insure that expression of genes on sex (X) chromosomes is kept equal in the different sexes," she explains. "Some organisms have evolved the means to compensate for the different number of sex chromosomes. Mammals inactivate one of the two chromosomes in females; the fruit fly compensates by hyperactivating the single X chromosome in males to raise the level of the X-specific gene expression to be equal to that found in XX females."

Professor Meyer was appointed to a Whitehead Institute Career Development Professorship in 1985. The endowed chair not only represents encouragement, she says, it eases somewhat the search for funds elsewhere.

An academic career attracts Professor Meyer because it allows her the freedom to pursue basic research without the requirement of producing some marketable product or process.

She received the B.A. degree in biology from Stanford and began graduate study at the University of California, Berkeley. After two years, acting on advice of mentors, she accepted an invitation to continue her graduate work at Harvard.

Her doctoral research was based on work with lambda viruses, using the techniques of gene splicing to study the control of gene expression. On receiving the Ph.D., she was invited to join the faculty in the Department of Biology at MIT. But she decided to continue her training as a postdoctoral fellow with biologist Sydney Brenner of the Medical Research Council in Cambridge, England.

It was an important career decision. The techniques of recombinant DNA had made possible in the 1970s an enormous rush of discoveries concerning virus development and gene expression in bacteria, discoveries she had been associated with at Harvard. It would not be long, she reasoned, before gene expression in viruses would be well understood.

Professor Meyer decided to change her research focus to higher diploid animals with genetic systems orders of magnitude more complex than those of the virus. In that area of science, there would be problems sufficient to occupy several careers.

She spent three years working with Dr. Brenner, who began research on the genetics of nematodes and for several years operated the only major laboratory in the world with this interest. When Professor Meyer completed the fellowship in 1982, she began her appointment at MIT.

The program she has begun at MIT is one of only a couple dozen nematode research programs worldwide, established mainly by former students of Dr. Brenner.

While still at Harvard, Professor Meyer came to know molecular biologists at MIT and as a graduate student she spent one summer assisting MIT geneticist David Botstein in an advanced bacterial genetics course at the Cold Spring Harbor Laboratory in New York. The MIT scientists exhibited what she considered to be a rare degree of interaction and cooperation with each other. Moreover, she says, the MIT group struck her as people who "really cared about students and junior faculty and about the quality and rigor of science."

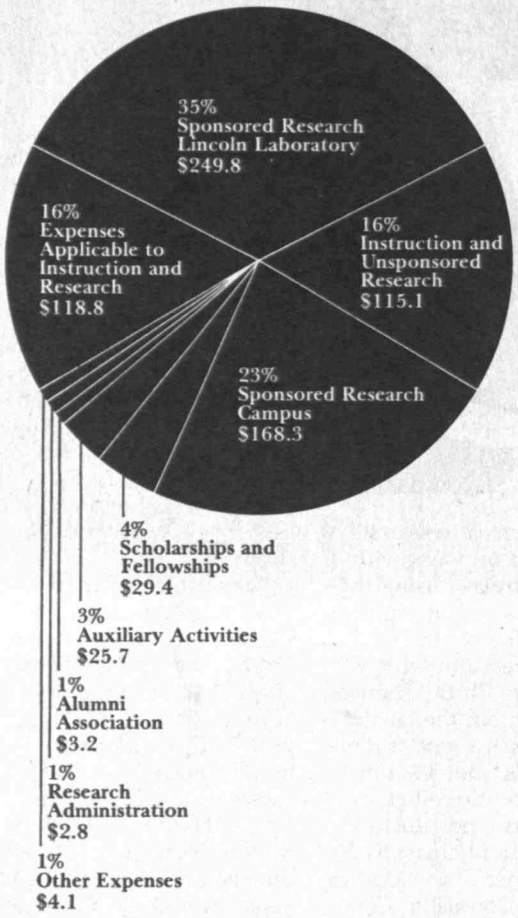
If there has been a surprise for Professor Meyer at MIT, it has been as the result of her teaching.

"The students here are incredibly smart and excited about their work," she says. "It's delightful to see their minds mature scientifically."

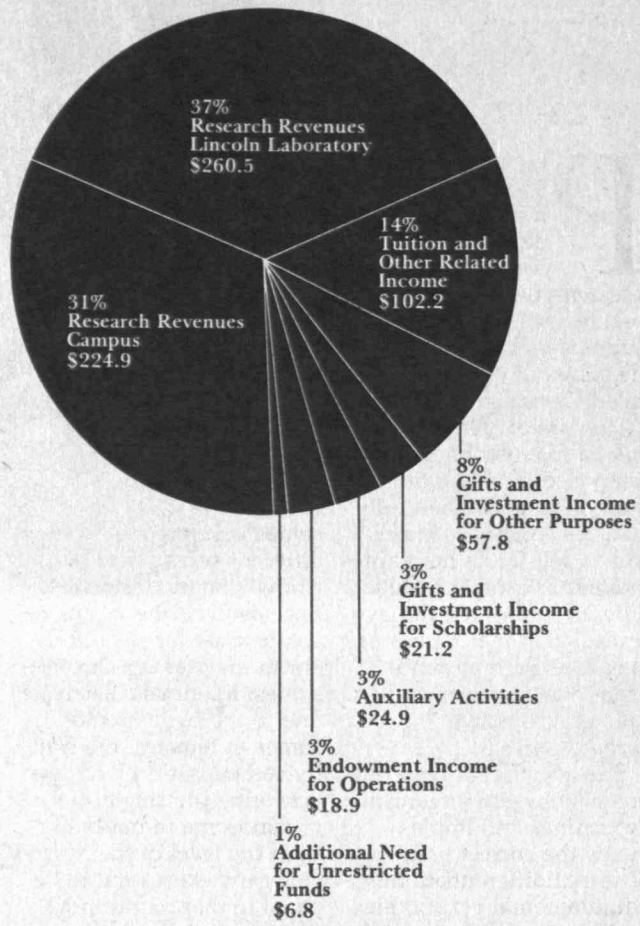
Outside the laboratory, Professor Meyer has enjoyed mountain hiking since her student years in California. She has hiked trails throughout the U.S., Europe, and Asia, including one memorable trip that took her to the Himalayan mountains of Nepal.

PHOTO: CALVIN CAMPBELL

1984-85 Operating Expenses (in millions)
Total: $717.2



1984-85 Revenue and Funds Used (in millions)
Total: $717.2



Finances

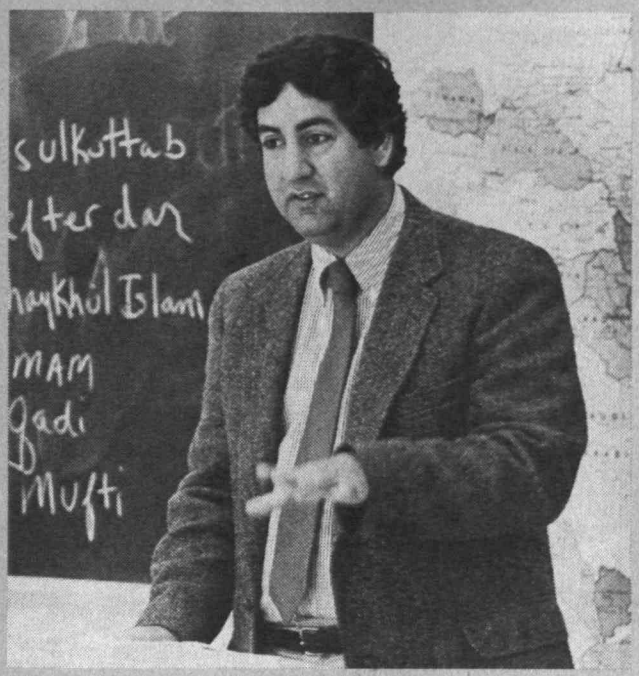
As reported by the Vice President for Financial Operations and the Treasurer, the total cost of operating the Institute during the past year was $717.2 million, up nine percent over 1983-84. Gifts and investment income met only 14 percent of these costs. Tuition and fees provided another 14 percent; and auxiliary activities — room, board, and the MIT Press — provided three percent. Sponsored research — both on campus and at Lincoln Laboratory — met 68 percent of the Institute's operating expenses.

Although sponsored research forms an important part of the Institute's educational program, too heavy a reliance on research funds is potentially dangerous: these funds can and do fluctuate severely, according to short-term government and business interests. Consequently MIT must work hard to ensure that its own long-term sources of funding — endowment funds — are sufficient to provide a buffer against other variations.

In recent years, MIT's endowment has shown significant growth in absolute dollars. The Institute ploughed a hard-won $1.5 million of operating surplus from 1985 back into current invested funds. At the same time, the market value of endowment and similar funds, after spending of income, has increased at an average compounded rate of almost 13 percent per year since 1978.

Despite this growth, endowment and investment income available for operations have actually declined relative to the more rapidly rising operating budget. The research universities with which MIT is most often compared typically have much larger endowments relative to operating budgets. In a recent survey of colleges and universities, MIT ranked seventh in the absolute size of its endowment, but fell to 19th in endowment per student and to 33rd in endowment per faculty member.

Gifts from alumni and other benefactors increased 26 percent during the past year, to an all-time high of $61.7 million. However, the small amount of gift income available for discretionary spending (rather than tied to specific purposes designated by donors) had to be used for current operations, rather than added to endowment. Ideally, to protect the Institute's future, *all* unrestricted revenues should be added to endowment.



PHILIP S. Khoury, a 36-year-old American-born student of Middle Eastern history and politics, brings to his teaching and research at MIT the qualities of rigor and detached analysis that the traditions of scholarship demand.

But when talk turns specifically to Beirut and Lebanon of today, his otherwise cheerful countenance takes on a touch of despair.

Lebanon is the land of Professor Khoury's forebears. His family still has relatives in Beirut, where Moslems are fighting other Moslems and Christians are fighting other Christians in what seems to him like the mindless conduct of war for its own sake.

"It is madness," says Dr. Khoury, associate professor of history at MIT and since 1984 the holder of an MIT Class of 1922 Career Development Professorship. "Some experts suggest that it's beyond the point where historians and political scientists can offer explanations. I'm not certain. But it's up to psychiatrists and psychologists to help us understand what is happening there now."

So concerned is Professor Khoury that he recently began to focus his research on the phenomenon of war itself, on how wars have reshaped political, social, and economic life in the Middle East and on what wars have done to usher in new systems of ideas in the region.

For MIT, Professor Khoury has introduced teaching and research in Middle Eastern history and civilization where none existed before he arrived. A subject he developed in comparative 20th century history of the region draws a large number of undergraduates plus a host of auditors—students and faculty eager simply to understand events they hear about almost every day from news media. Professor Khoury believes that a second subject he developed—this one on comparative history before World War I—offers even more insight into the roots of contemporary events in that area of the world.

Professor Khoury was born and grew up in Washington, D.C. His late father, who immigrated from Palestine, practiced law there for many years. Professor Khoury's mother, a member of a family of Lebanese intellectuals, gave up a career as professor of sociology at the American University in Beirut immediately following World War II to represent her country in the United Nations. It was in Washington that she met and married Professor Khoury's father.

Professor Khoury received the Ph.D. in history and Middle Eastern studies from the the Center for Middle Eastern Studies at Harvard University in 1980. The focus of his studies was Syria in the 19th and early 20th centuries, and his most recent book, *Syria and the French Mandate* (Princeton University Press).

While at Harvard, Professor Khoury spent several years engaged in research in Egypt, Lebanon, Syria, and France, as well as at Oxford University in England. In Cairo he met another American-born Middle Eastern scholar who was to become his wife, Mary Christina Wilson, now a professor of Middle Eastern history at New York University. They live in Cambridge and not infrequently collaborate on papers.

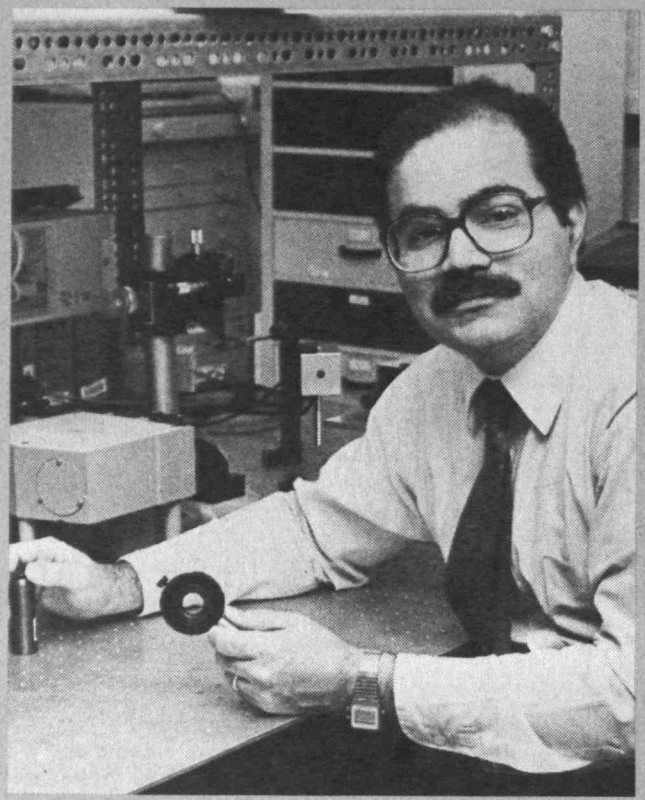
Professor Khoury was courted by Stanford, but accepted instead a faculty appointment at M.I.T. During his years at Harvard, he says, he became increasingly aware of growing strengths at MIT in history and the social sciences. He decided that it was here that he would have the opportunity to introduce Middle Eastern studies and eventually build an integrated program of Middle Eastern teaching, research, and related activities.

He has collaborated with scholars in MIT's Aga Khan Program for Islamic Architecture on comparative studies and development of Middle Eastern cities. And his Class of 1922 career development appointment has allowed him time to pursue more deeply his interests in comparative urban history and nationalist movements in the Middle East, as well as initiate work on war and society in that region.

This year the family of the late Emile Bustani, '33, of Beirut provided funds for a series of Middle Eastern seminars to be directed by Professor Khoury under the auspices of MIT's Center for International Studies.

The grant held special meaning for Professor Khoury. It was his grandfather—a noted professor of astronomy and mathematics at the American University in Beirut—who recognized Mr. Bustani as a potentially gifted engineer and directed him to MIT, despite Mr. Bustani's meager resources. Here, the young Lebanese received his degree in civil engineering; then returned home to form a company that eventually became the most prominent construction firm in the Middle East.

PHOTO: CALVIN CAMPBELL



To some, Raphael C. Lee, M.D., Sc.D. '79, might appear to lead a double life.

In one incarnation, on the Boston side of the Charles River, he is a plastic and reconstructive surgeon. He is on the surgical staffs at Children's, Brigham and Women's, and New England Deaconess Hospitals, where, among other things, he corrects and reattaches severed and disfigured hands and fingers. And he is an assistant professor of plastic surgery at the Harvard Medical School, where he supervises resident surgeons as they learn the art of reconstructive surgery.

On the Cambridge side of the river, in MIT's Department of Electrical Engineering and Computer Science, he is Karl Van Tassel Career Development Assistant Professor. Here he does research in the electromechanics of cartilage and connective tissues and teaches the electrophysiology of cells and tissues to electrical engineering students. On the faculty of the Harvard-MIT Division of Health Sciences and Technology, he teaches still other subjects in the anatomy of the hand and face.

Professor Lee sees the lines of work he pursues simultaneously in Boston and Cambridge as converging into one seamless, scientific career with well-defined goals. First, he hopes to discover how electrical and mechanical forces regulate the development of tissues. Second, he hopes to develop materials with the necessary mechanical and biochemical properties to substitute for vascular and skeletal tissues in humans.

In 1981 he was named a MacArthur Prize Fellow by the Chicago-based John D. and Catherine R. MacArthur Foundation, and in 1985 he was selected by *Science Digest* magazine as one of America's 100 outstanding scientists under the age of 40.

One of five children in a black professional family of Charleston, South Carolina, Professor Lee had no original ambition to become a physician like his father or like several other forebears. Instead, he opted for electrical engineering, receiving the B.S.E.E. from the University of South Carolina in 1971. But he was led back to medicine by what he perceived to be a unity and a commonality between engineering and biology. He pursued a double degree program of engineering at Drexel Institute of Technology in Philadelphia and medicine at nearby Temple University School of Medicine, receiving the M.S. from Drexel and the M.D. from Temple in 1975.

After Temple and Drexel, Professor Lee won his surgical internship appointment at the University of Chicago Hospitals.

By then, however, he had become acquainted with Professor Alan J. Grodzinsky of MIT's Department of Electrical Engineering and Computer Science, who was studying the dynamic coupling of electrical and mechnical stresses in biological tissues. Moreover, Professor Lee had begun to concentrate his surgical interests on connective, vascular, and skeletal tissues. These are the tissues of primary concern to reconstructive surgeons and also the tissues which many believe are profoundly susceptible to electrical and mechanical forces.

In 1977, the University of Chicago granted him both an unusual leave of absence from his residency and a two-year surgical research appointment to help support doctoral studies at MIT under Profressor Grodzinsky. While a doctoral student at MIT, Professor Lee was also a research fellow in Orthopedic Surgery at the Harvard Medical School, working at Children's Hospital. Professor Lee's thesis research for the Sc.D. focused on electromechanical properties of cartilage.

He then completed his surgical residency in Chicago before returning to Boston in 1981 as resident in plastic surgery at the Massachusetts General Hospital and a principal research scientist at M.I.T.

Over the past two years at MIT, Professor Lee and his colleagues have developed a model tissue which permits the study of the effects of applied electrical fields on cellular metabolism and have demonstrated that small electrical fields can produce changes in cellular biosynthesis.

Beyond that, the MIT laboratory he has established is as unique as Professor Lee himself in that it permits a wide range of bioengineering experiments to be carried out with living mammalian cells.

PHOTO: CALVIN CAMPBELL

Physical Plant and Campus Environment

The Arts and Media Technology Building was substantially completed by the end of the year. The first occupant, the Committee on the Visual Arts, moved into the building during January and the Albert and Vera List Visual Arts Center was dedicated in March with opening exhibitions of contemporary painting, sculpture, and performance art in the Center's three galleries.

Major renovation projects completed during the year included the Martin Center for Engineering Design on the fourth floor of Building 3, Chemistry research laboratory facilities on the second and third floors of Building 2 (north), and the Center for Real Estate Development on the top floor of the Armory (W31) on Massachusetts Avenue. Athena renovation projects continue to be a major source of design and construction activity, with seven new computation clusters slated for completion during the next year.

The first phase of the campus computer network has been completed. This network has been designed to provide high-speed data communications to as many on-campus computer systems as possible. Gateways connecting the campus computer network to local area networks are located in a number of campus buildings. The major network client, at present, is Project Athena.

In the Housing and Food Services area, substantial changes were implemented in an effort to assure that we continue to meet our goal of providing the best possible services for our students. The Housing operation was reorganized to decentralize much of the immediate decision-making authority and responsibility by moving it to the individual House Managers.

More than $1 million in renovations and repairs was spent in an ongoing effort to upgrade the housing system. Major structural work took place at East Campus where extensive lintel and brick restoration was performed. New bathroom construction was also completed. At the West Campus houses, a recarpeting program was initiated. A comprehensive program for mechanically updating elevators located in Housing and Food Services department areas was also implemented.

The Food Service operation in the majority of dormitory dining rooms was changed to an à la carte system during the year in response to the students' desire for variety and flexibility. Baker House residents did express a desire to continue its Commons dining program, with some à la carte adjustments to meet their dining objectives, and will be the only House on a Commons dining plan next year.

So that the Faculty Club might better serve its primary function as a center of academic and social exchange, the Advisory Board and management of the Club recommended a full-scale renovation, which began this summer.

Career Services and Preprofessional Advising

In spite of the slowing of the economy and of a marked pause in the growth of the electronics industry, which has been the destination of large numbers of MIT graduates in recent years, it was a good year for graduates seeking employment. The number of companies and government agencies which came recruiting totaled 431, not much short of 1982's record of 450. (The number compares with 405 in 1982-83 and 407 in 1983-84.)

If the change in the economic climate was apparent anywhere it was in the level of salary offers. Offers to seniors in electrical and mechanical engineering were up less than 4 percent; offers to seniors in chemical engineering did not move up at all (with the result that chemical engineering dropped to second place, below electrical engineering, in the ranking of undergraduate majors by salary). The largest salary increases in engineering — up to 8 percent — were at the Ph.D. level. The premium paid for a Ph.D. degree in electrical engineering over a bachelor's, which was down to 1.4 five years ago, is back to 1.6 (where it stood in 1974).

One field on which the sun certainly shone, however, was architecture. As many as half a dozen firms came recruiting — a rare event because most of the time architectural firms count on candidates coming to them — and salaries were up as much as 10 percent.

For the second year in a row there was an increase in the number of MIT applicants to medical school. They totaled 115, including 81 undergraduates, 10 graduate students, and 24 alumni. (There were 105 applicants in 1983-84 and 101 in 1982-83.) The increase runs counter to a leveling in the number of candidates in the country at large. The final results are not in, but it appears that 88 percent of the undergraduate applicants and 80 percent of the total applicant group were successful. This compares with a national acceptance rate of 48 percent.



ASSISTANT professor of chemical engineering T. Alan Hatton came to MIT nearly four years ago to launch his career in academic research and teaching. That he's made a splendid beginning, is evidenced by his earning MIT's Everett Moore Baker Award for Excellence in Undergraduate Teaching in 1983 and this year being one of 200 researchers nationwide to receive a Presidential Young Investigator Award from the National Science Foundation.

But when he goes home at night, Professor Hatton finds himself in what he calls a "separate life," that of a faculty resident at MacGregor House, one of MIT's undergraduate dorms. It's a role he and his wife, Marianne, never imagined for themselves.

"But it's turned out great," he says, "knowing students on a personal level and being involved with them in their lives outside the classroom and laboratory. This is what university life is all about."

The Hattons came to the United States from their native South Africa in 1977. He was beginning graduate studies in chemical engineering at the University of Wisconsin, where he received the Ph.D. in 1981. His experience teaching a senior undergraduate course in mass transfer at Wisconsin convinced him that teaching would enrich the career he had already planned in research. He considered himself fortunate, then, when he was appointed in January of 1982 as Atlantic Richfield Assistant Professor of Chemical Engineering at MIT.

"I knew it was a department on the move, heading for number one in the nation, with new faculty and excellent graduate students," he says.

Professor Hatton plunged ahead immediately. In his first three years, he supervised the thesis research of a dozen doctoral candidates, served as reader for another dozen, and supervised research by one S.M. candidate and five S.B. candidates. Moreover, he has developed and directs a new departmental chemical engineering process laboratory for undergraduates. The laboratory integrates classroom teaching with experiments in biochemical fermentation, combustion, chemical separations, and extraction by liquid membranes. For the summers of 1983 and 1984, Professor Hatton directed the department's practice school at Brookhaven National Laboratory.

His own research has flourished, now drawing support from six industrial concerns and the National Science Foundation as well as MIT's own Sloan Basic Research Fund. Professor Hatton has been the coauthor of nearly two dozen papers published or soon to be published in professional journals, and has lectured and participated in symposia all over the U.S. and in Europe.

Specifically, his research interest is in exploring methods of extracting biologically valuable molecules (such as amino acids and proteins) from the heterogeneous "soups" that are the end products of biotechnology processes. His long-term goal is to identify and describe those separation processes that will prove commercially valuable to the still-emerging biotechnology industry.

For example, he and his colleagues are pioneering research into the use of organic solvents (normally unsuitable for protein extractions) in the recovery of biological macromolecules. Their initial success on the separation of simple protein mixtures has prompted Professor Hatton to look at more interesting problems, such as the recovery of the protein interferon using this technique.

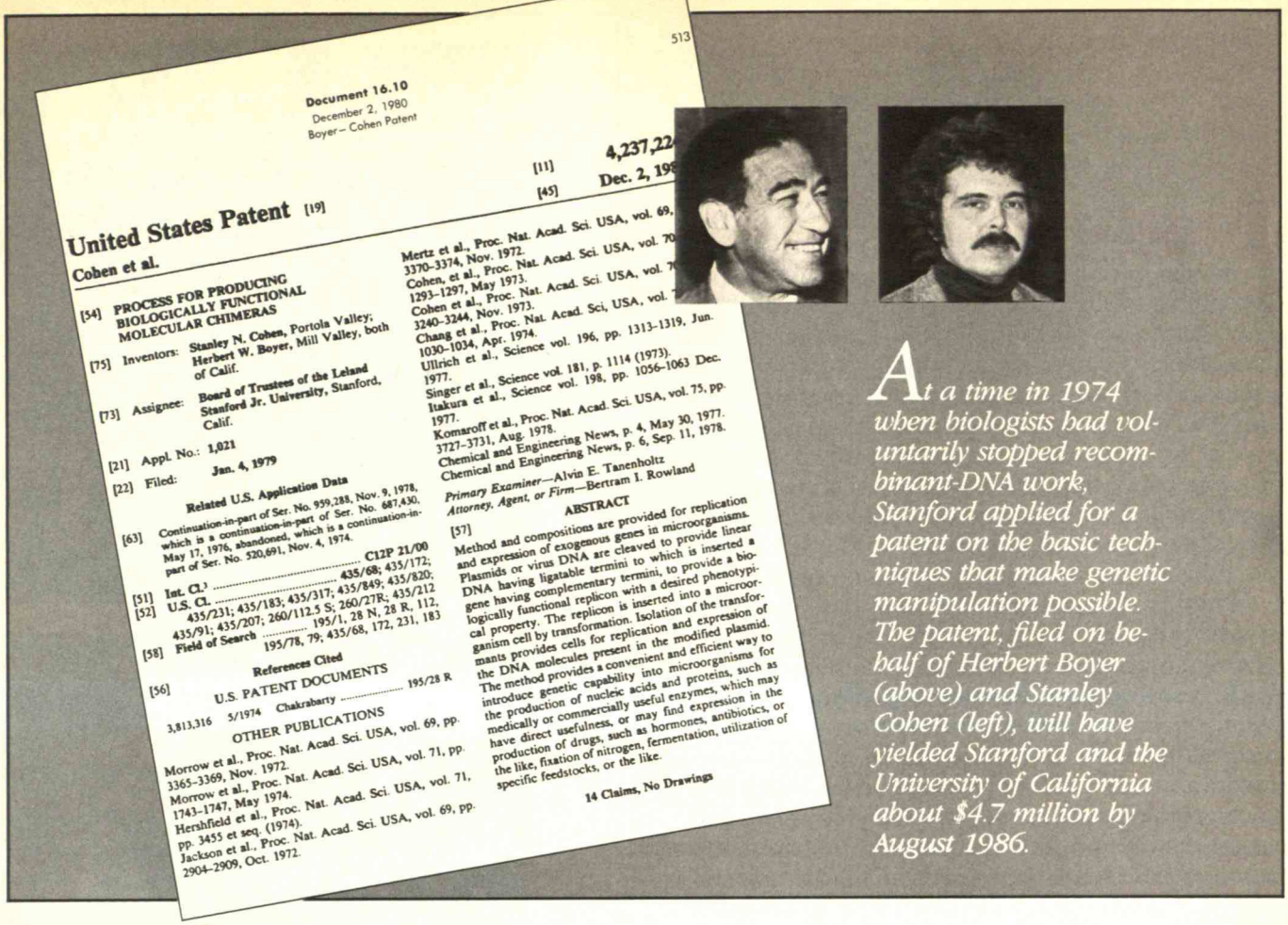
The Atlantic Richfield Career Development Assistant Professorship that he held for his first two years at MIT played an important part in his early achievements, he says, providing equipment, supplies, and, most essential, student research support.

In mid-1983 his colleagues, impressed with Professor Hatton's interest in and rapport with undergraduate students, suggested that he and Mrs. Hatton consider serving as family residents in one of the undergraduate dorms, where they would function as counselors, crisis managers, and supervisors.

Following a series of interviews in which their older son, Ross, then 16 months old, proved to be the star, the family moved into an apartment at MacGregor House. Their second son, Kent, now a year old, was born after they became faculty residents. The boys are the ice breakers, helping the Hattons to form close friendships with students.

"The most valuable thing for me has been to come to know each student as a human being and not just as one in a mass of undergraduates," Professor Hatton says. On a more somber note, he adds: "The students who come to MIT are fundamentally extraordinary people and they should not be failing. But a few do and not just for reasons of inability. . . . These are the people we really try to reach."

PHOTO: CALVIN CAMPBELL



At a time in 1974 when biologists had voluntarily stopped recombinant-DNA work, Stanford applied for a patent on the basic techniques that make genetic manipulation possible. The patent, filed on behalf of Herbert Boyer (above) and Stanley Cohen (left), will have yielded Stanford and the University of California about $4.7 million by August 1986.

should not be able to receive fees from patenting them. Others confessed to being "generally disturbed" about the use of patenting to control ideas and the dangers of commercialism. These scientists were expressing the same fears and concerns about patenting that had disturbed others decades earlier.

In 1980 two major changes opened the gates to commercializing the results of biological research. First, in a five-to-four ruling the Supreme Court held that a "live human-made" microorganism with "markedly different characteristics from any found in nature and one having the potential for significant utility" is a "manufacture" or "composition of matter." Thus it "plainly qualifies as patentable subject matter." The Court acknowledged the potential dangers of genetic research, the reality of significant ethical concerns about the "specialness" of life, and the tension between proprietary interests and the public good. However, the majority believed that Congress could pass legislation to deal with these larger questions. Meanwhile, Congress was concerned with making it easier for industry to commercialize the results of federally supported academic research. In December 1980 Congress passed the Patent and Trademark Amendment Act. This act enabled universities, nonprofit institutions, and small firms to receive patents directly, to license patent rights, and to collect royalties on inventions stemming from federally funded research without seeking waivers from federal agencies. The legislation went far beyond the patent agreements previously made between certain agencies such as NIH and universities.

The New Status Quo

The door was open for academic scientists and their universities to pursue the commercial aspects of biotechnology. Many were still worried, however. The Supreme Court decision and Congressional action received wide press coverage. This publicity stimulated debate about the ethical effects of private ownership of life forms, and whether universities should profit from the commercial uses of publicly funded research. As more and more academic biologists took on entrepreneurial roles, university presidents voiced concerns that although they were interested in pursuing greater ties with industry, serious problems remained. Derek Bok, president of Harvard, noted that "the new-found concern with technology transfer is disturbing not only because it could alter the practice of science in the university but also because it threatens the central values and ideals of academic research."

Throughout this period, biologists complained

PHOTOS: WIDE WORLD

about the mistrust among colleagues involved with competing companies, and the reluctance of some scientists to reveal the full details of their work for fear of losing patent protection. Biologists were also concerned about increasing restrictions on the free flow of cell lines, plasmids, and bacterial strains essential for research in the rapidly developing field. Yet others felt that the turbulence of the early 1980s merely reflected the uncertainty and inexperience of a newly commercialized field, and that the situation would stabilize after the "transition" period.

What has happened since then? Biology has been transformed and so have the biologists. Virtually overnight, academic biologists never before involved with industry have become consultants, advisors, founders, equity holders, and contractees of new biotechnology firms or new divisions of multinational corporations. Patenting has become the norm in university biology departments. Today controversy focuses mainly on the distribution of the returns among researchers, their department, the university, and the sponsoring company. The unproven assumption is that patenting will serve the public, which has financially supported most of the research, regardless of the arrangement.

As in the past, problems grow when patents pay off and universities take steps to protect their patents and maximize their returns. The Stanley Cohen/Herbert Boyer patents on the basic recombinant-DNA process have recently rekindled controversy. Stanford describes the patents as "extraordinarily basic," providing "a proprietary position—until 1997—over the basic methodology and tools currently used throughout the biotechnology industry." About 75 companies have agreed to pay a $10,000 minimum annual royalty for the rights, and these fees will have yielded about $4.7 million for Stanford and the University of California by August 1986.

When Cetus, a major biotechnology firm, announced in January 1985 that it was dropping its license, Stanford made it clear that it would defend the patent vigorously against unauthorized use. The university had already allocated $200,000 of the patent income as a "war chest" for litigation. Later in the year the two parties reconciled their differences and Cetus remained in the fold. Once again it became clear that a patent is only as good as one's willingness and ability to defend it. However, there was concern that by acting like a business, Stanford may impair its public image as an educational and research institution.





The fears about the effects of patenting and commercialization voiced in the early 1980s persist as biotechnology moves into high gear and universities and industry gain experience in the field. Articles and editorials in the trade press attest to "creeping concealment" of research results at biotechnology conferences, and report of "tensions," "reluctance to share data," and "an obsession with secrecy" among graduate students who work in their professors' university and industrial laboratories. Patent attorneys at universities and in the pharmaceutical industry note that the free exchange of plasmids and cell lines has indeed been limited, an effect that could hamper further development of biotechnology.

New notions of ownership are challenging the expectations of the biomedical community and the public. For example, scientists at the University of California at Los Angeles recently used a cell from patient John Moore's body to establish a cell line for research. The university patented the cell line and licensed it to two biotechnology firms that are now using it to produce several potentially valuable substances, including interferon. Moore sued in October





Early in the history of recombinant-DNA research, many biologists were concerned about the safety of their work. At the famous Asilomar conference in 1975, a group of biologists, including Nobel laureate David Baltimore (third from left, bottom photograph), discussed the possible hazards of these experiments and how they might be minimized. At a National Academy of Sciences forum in 1977, a small minority voiced the concern that patenting of recombinant-DNA techniques might sway scientists' perception about the safety of genetic engineering.

1985, asking for compensation. The bizarre question of whether a medical patient owns his or her cells is a matter for the courts to judge. However, the situation inevitably creates mistrust between patients and biomedical researchers.

Especially disheartening is the bitter dispute over patent rights for the procedure to detect antibodies to the AIDS virus in blood. The Pasteur Institute in Paris has sued the U.S. government, contending that the NIH patent application on the procedure ignores the role of French researchers in the discovery. Because of this conflict, collaboration between the leading research groups in the United States and France has deterioriated, and the pace of research on this major health problem may suffer as a result.

The Credibility Gap

Perhaps most telling, the dual roles that many biologists play have begun to impair their credibility on matters of public concern. For example, Mark Ptashne, then head of Harvard's Department of Biochemistry and Molecular Biology, testified in 1981 at a hearing in Somerville, Mass., on the safety of recombinant-DNA research. The hearing was called to consider possible safety hazards associated with the laboratory that a new biotechnology firm wanted to open in Somerville. The Harvard biology head was also the major scientific figure in the company. One alderman dismissed his testimony, saying "You're more than a scientist now. You're a businessman."

The commercialization of academic biology can create conflicts of interest that may seriously erode public trust. This comes at a time when biologists' expert advice is urgently needed on questions of public policy. These questions range from deciding priorities in the application of biotechnology, to whether genetically engineered organisms should be deliberately released into the environment, to the ethical implications of human gene therapy, to the use of biotechnology in developing biological weapons. These questions must be decided with full public participation, and biologists have an important role to play in the deliberations. But their commercial roles may well affect their perceptions and limit their effectiveness as credible public advisors.

Despite all these problems, the prevailing mood in government, industry, and university biotechnology circles is to accept the new status quo. The major emphasis of university administrators is on strengthening university-industry links, and they see patent-licensing arrangements as a way of increasing such ties. At the same time, industry has made it clear, in congressional testimony and through actions at several universities, that it cannot be relied upon as a major source of stable support for academic research.

In the meantime, little attention is being paid to alternatives that could avoid the pitfalls involved in patenting and commercializing the results of academic research. These alternatives include developing patent-pooling arrangements among universities and creating new public institutions such as a national nonprofit patent-handling body that would transfer the results of academic research to the public. Universities could also transfer patents relating to important public-health problems to international agencies such as the World Health Organization. These and other alternatives should be seriously explored to ensure that the fruits of biomedical research are used wisely to serve the public interest. While past experience gives us little reason for smug satisfaction with the status quo, it does provide perspective to help us do better in the future. □

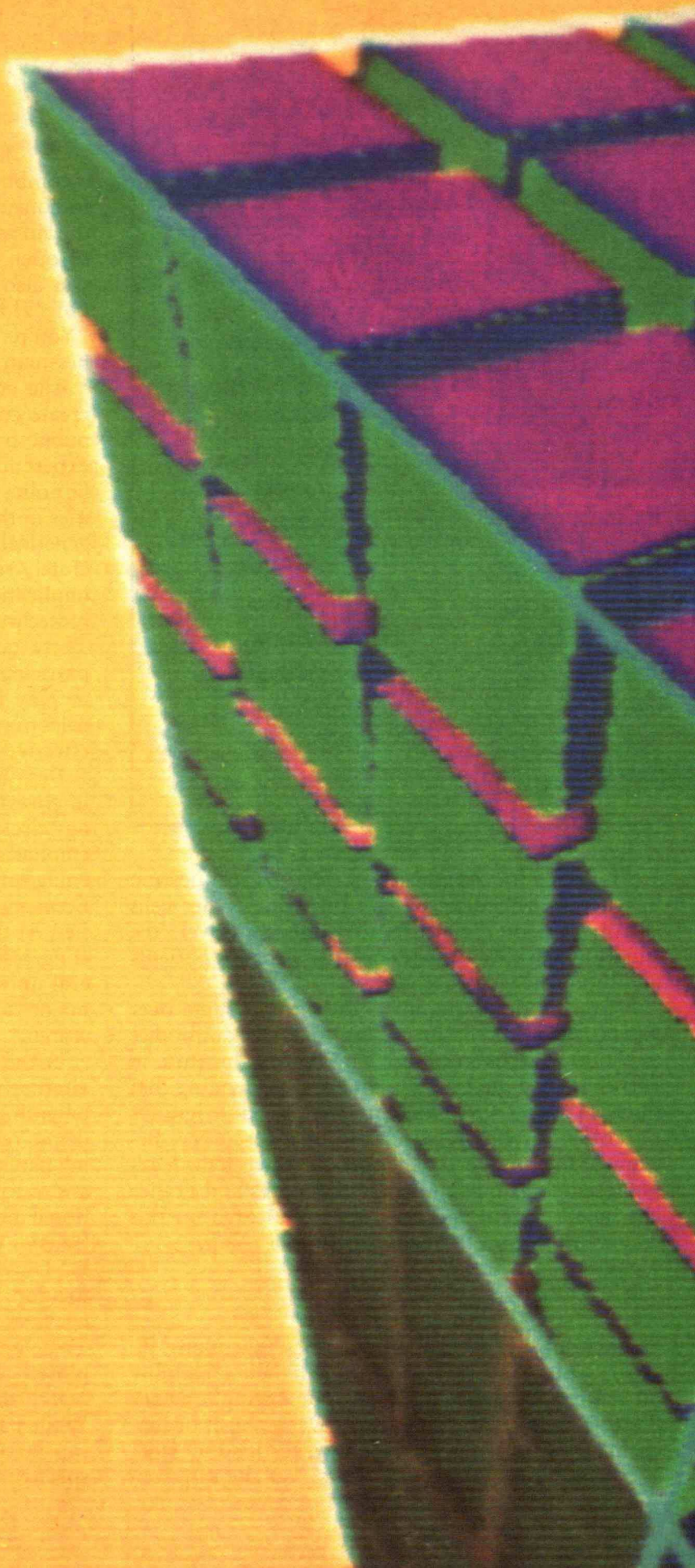
A revolution is taking place within the information revolution. It involves harnessing hundreds, thousands, or even millions of computers to work together on a single task.

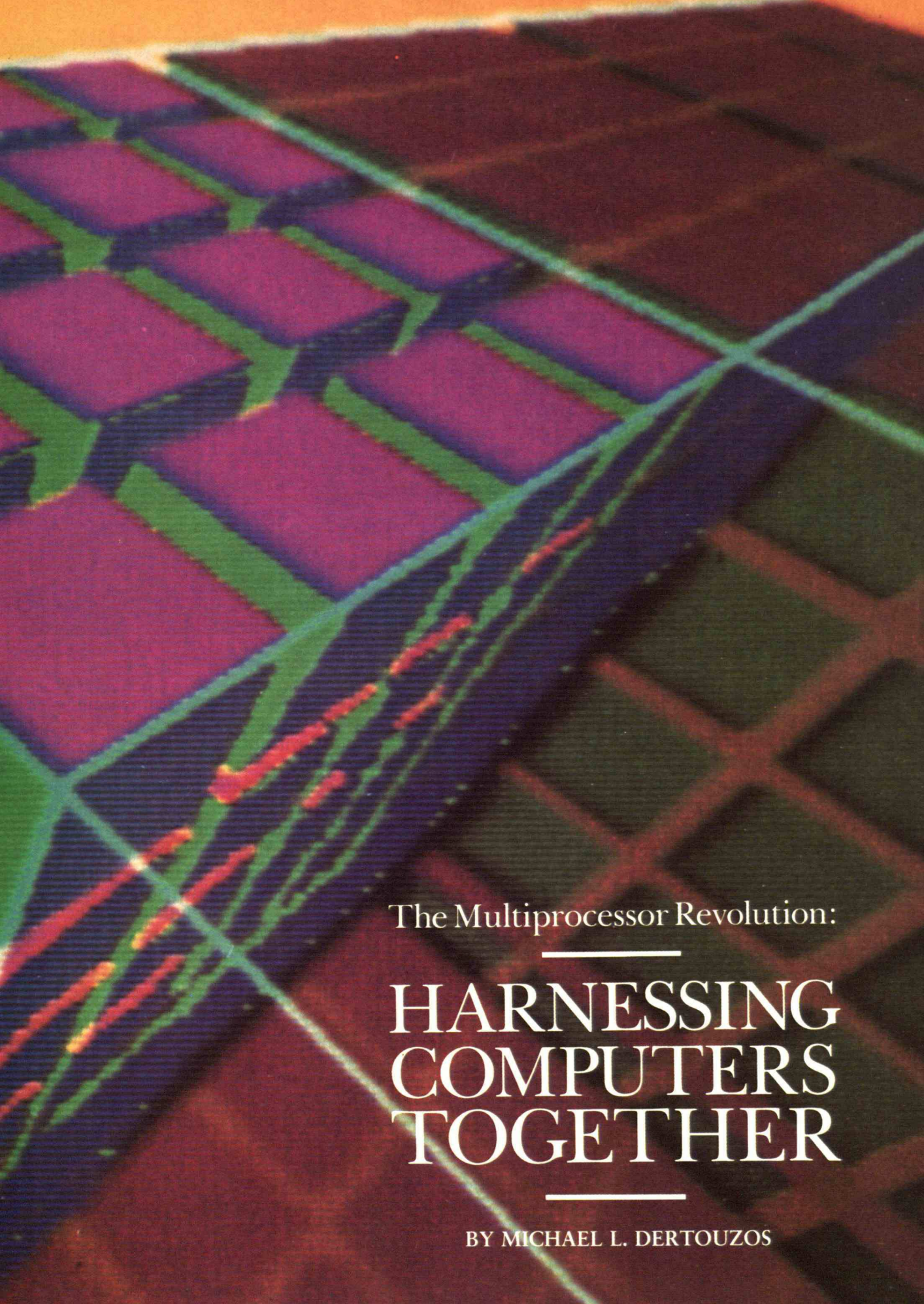
The technical and economic forces spurring this revolution arise from two important trends. On the one hand is the dramatic improvement over the past two decades in very-large-scale-integrated (VLSI) circuits, which now incorporate some hundred-thousand components on a silicon chip. The cost of computational power on chips has dropped an average of 30 percent annually. For less than $100 manufacturers can now fabricate a microprocessor—the computational core of a computer etched on a single chip—capable of performing more than a million instructions per second.

On the other hand, it is becoming disproportionately expensive to construct a single processor, using a number of chips or other components, that can perform calculations appreciably faster than a microprocessor. The world's fastest computers, with only 500 times the performance of a microprocessor, cost 200,000 times as much. Moreover, these large machines cannot be

New computing machines could not only be much faster and cheaper, but could achieve the elusive goals of recognizing images, understanding speech, and exhibiting more intelligent behavior.

ILLUSTRATION: TOM NORTON

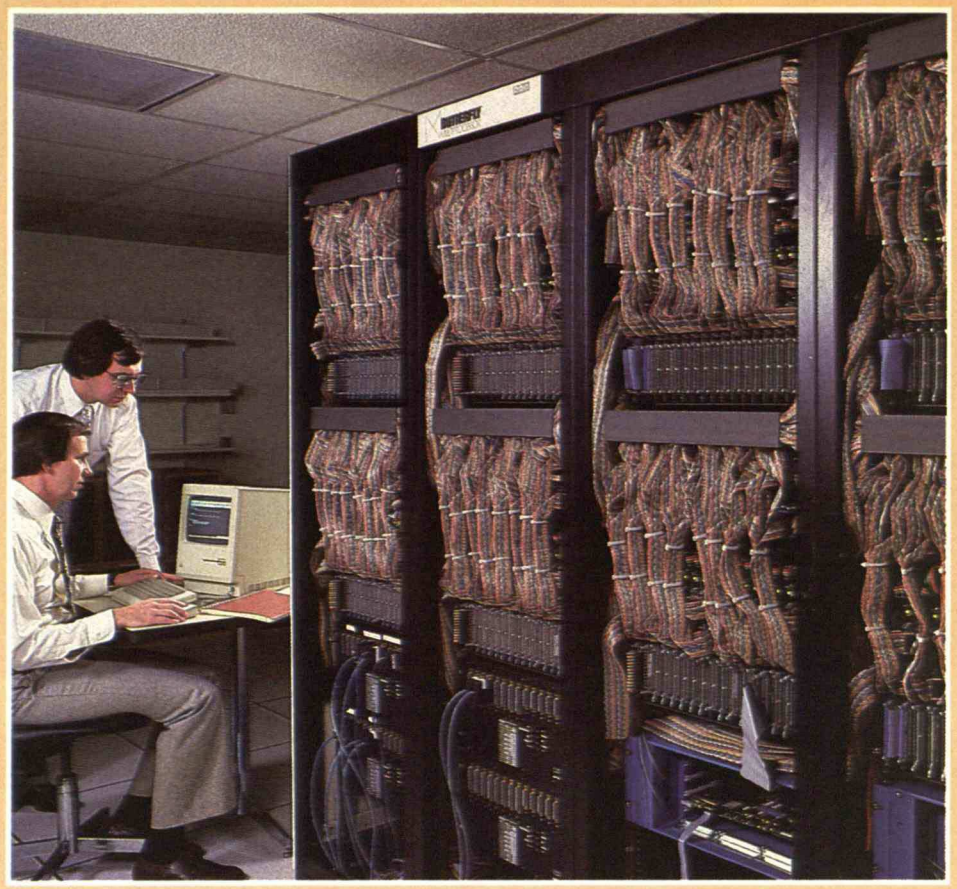




The Multiprocessor Revolution:

HARNESSING COMPUTERS TOGETHER

BY MICHAEL L. DERTOUZOS



Bolt, Beranek and Newman of Cambridge, Mass., uses this multiprocessor for high-speed computation. While a standard computer has one processor that performs calculations, this machine has 128 processors that work simultaneously on a single problem. Multiprocessing may reduce the costs of building fast computers, and there is no foreseeable limit to the speeds multiprocessors may achieve.

improved much further because they are pushing against the ultimate limit: the speed of light. They already perform one instruction every 2 billionths of a second, but because electrical signals cannot travel faster than light, information takes at least that long just to move a couple of feet from one part of the machine to another.

By harnessing many relatively inexpensive VLSI processors together into a multiprocessor system—sometimes also called a parallel- or concurrent-processor system—we may significantly reduce the cost of achieving today's fastest computing speeds. More important, there is no foreseeable limit to the speeds we may be able to achieve through multiprocessing. Many of us harbor expectations that this new breed of machines will make possible some of our most romantic and ambitious aspirations: with appropriate programs, these new machines may recognize images, understand speech, and behave more intelligently.

Even anthropomorphic evidence suggests that if computers are to perform intelligently, many processors must work together. Consider the human eye, where millions of neurons in the retina, optic nerve, and visual cortex cooperate to help us see. Or consider the cerebellum, where over a trillion cells share the complex task of higher-level thinking in yet unknown ways. What arrogant reasoning led us to believe that a single processor capable of only a few million instructions per second could ever exhibit intelligence?

To my thinking, the massive quantitative increase in computing power promised by the multiprocessor revolution is a prerequisite to the much-touted qualitative increase in the intelligence of future computers. Of course, merely throwing lots of computing power at difficult artificial-intelligence problems will not necessarily solve them. Otherwise, the use of superfast single-processor computers would have already yielded more progress in this area. But establishing a technology in which an unlimited number of processors can cooperate effectively sets both a machine foundation and a mind set for tackling these difficult problems in a new way. It is my hope and expectation that the additional ingredients we need to achieve greater artificial intelligence—further study of biological intelligence and development of new models for machine vision, hearing, and intelligence—will flourish on this new multiprocessor foundation.

Several dozen research groups in universities and industry are exploring multiprocessor systems. A few computers on the market already use several cooperating processors to solve large problems in high-

PHOTOGRAPH: LITTLEWOOD COMMUNICATIONS

What arrogant reasoning led us to believe that a single processor could ever exhibit intelligence?

energy physics, aerospace engineering, and computer-aided design of products such as computer chips and airplanes.

The promise of the multiprocessor revolution entices and seduces researchers. The outcome of our efforts depends on developments in the three crucial areas that I will discuss: designing architectures for multiprocessors, programming them, and applying them. The value of multiprocessor systems will ultimately rest on our ability to tackle bigger problems simply by using more processors. This "computation by the yard" approach may open the door to a new and more useful world of information technology.

Uses of Multiprocessors

Some traditional information-processing problems require enormous number-crunching power—solving the equations required to predict the weather, calculate the effects of nuclear explosions, or solve certain quantum-mechanics problems. Multiprocessors are likely to be useful for such applications because these problems can typically be decomposed into many interlinked subproblems that can be handled concurrently. For example, a large calculation to predict weather changes over a 1,000-square-mile area could be broken down into 100 smaller calculations, each covering a 10-square-mile cell. These smaller calculations could be performed concurrently by 100 processors. Periodically, the processors would communicate with one another about the weather changes at the boundaries of their cells. Of course, handling these number-crunching applications more effectively, while important, does not constitute a multiprocessor revolution, since their effect on our lives has been and will probably continue to be modest.

On the other hand, replacing mainframe computers with multiprocessor systems that are even slightly cheaper could have a significant economic impact in banks, airlines, insurance companies, and other large organizations. And the prospects for such a change are good, since many business tasks can be broken down into relatively independent subtasks. For example, calculating and printing checks for company employees could be done by many processors working concurrently and almost independently. The processors would need to communicate with one another only about total payroll, tax, and benefit balances. In banks, multiprocessor systems could assign each account to some processor alphabetically or by account number. Concurrent deposit and withdrawal transactions would then be handled by the responsible processors. Airlines might break up centralized programs now used to book reservations, issue tickets, compute fares, and balance cargo. The work could go to several adjacent, communicating machines, corresponding perhaps to each major metropolitan area.

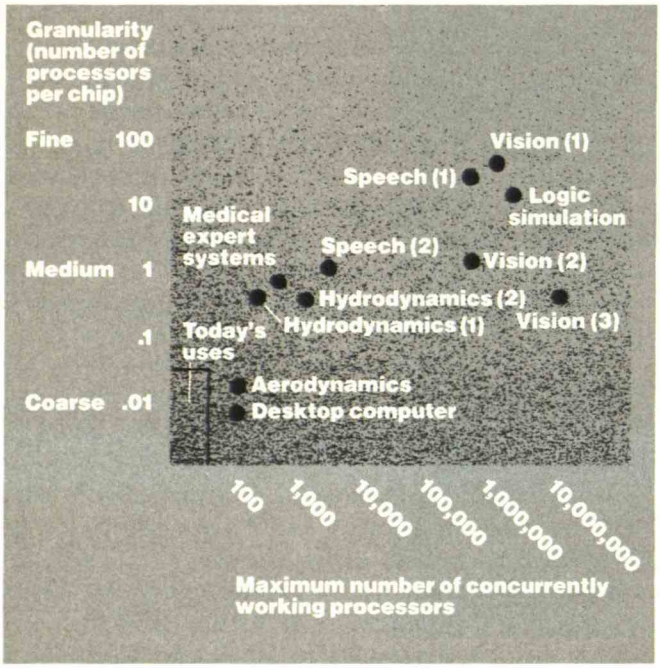
But the revolutionary promise of multiprocessors rests with their expected ability to achieve what is difficult or impossible for conventional computers—artificial intelligence (AI) applications involving functions such as seeing, hearing, learning, reasoning, and advising.

To understand the utility of multiprocessors better, I recently convened an M.I.T. workshop on the prospective usefulness of multiprocessors. The participants included some 25 leading researchers who are applying computers to a variety of fields, including medical diagnosis, aerodynamic design, and speech recognition. I asked them how many calculations could be carried out concurrently on future multiprocessor systems to solve problems in their areas. These specialists had to imagine how they might decompose operations now performed sequentially into relatively independent subtasks that processors could, with some intercommunication, perform concurrently. This mental task is difficult and cannot be done precisely, but it is not as tough as it sounds. It is similar, in terms of mental gymnastics, to what programmers must do today in decomposing a large task into subtasks to be executed in sequence, and into "utility subroutines"—subprograms executed frequently to carry out many of the higher-level tasks.

I also asked these researchers to identify the most desirable "granularity" of multiprocessor systems for their applications. Granularity is a measure of the size and complexity of the processors in a system.

MICHAEL L. DERTOUZOS is professor of computer science and electrical engineering at M.I.T. He is director of M.I.T.'s Laboratory for Computer Science, which developed time-shared computers and has pioneered in multiprocessor research over the last 15 years. He steered the LCS into this area and helped the Defense Advanced Research Projects Agency launch its multiprocessor program. A member of the group that founded the Microelectronics and Computer Technology Corp., he got this consortium of computer and semiconductor firms interested in multiprocessor research. Some of his prior research has been in personal computers, and in a People Magazine *interview 11 years ago, he predicted the revolution that later occurred in this field.*

Fine-grain systems have many simple processors (each chip may contain 100). Coarse-grain systems have fewer, powerful processors (each may contain 100 chips). Specialists at an M.I.T. workshop estimated the optimal number and granularity of processors for their applications. (Numbers in parentheses represent different researchers' estimates.) Sensory applications may use millions of fine-grain processors; deeper, cognitive applications may use hundreds of coarse-grain processors.



A fine-grained multiprocessor system has small, simple processors, but generally many of them. By my somewhat arbitrary definition, in a fine-grained multiprocessor, a single silicon chip has some 100 processors on it. A system with 10,000 chips would have 1,000,000 processors. A medium-grained system has more powerful processors, say 1 per chip. Such a system might have 10,000 chips and the same number of processors. A coarse-grained system has even more powerful processors—each one might be composed of 100 chips—but it might have only 100 processors in all.

The results of my survey show that tasks such as vision and speech recognition may profitably use millions of fine- and medium-grained processors working concurrently. Deeper cognitive applications and more traditional computing jobs are perhaps better handled through a few hundred coarse-grained processors. This conclusion makes intuitive sense. Thousands or even millions of hair-like cells in our ears and retinal cells in our eyes are concurrently stimulated by a single musical sound or a quick glance through a car window. Yet after these stimuli have been processed by our brains for a while, we are left with a more sequential, conceptual residue—"Aha . . . the opening bars of Beethoven's Fifth," or, "He veered to the right to miss the bicyclist and couldn't avoid the pole." Indeed, the very essence of reasoning or arguing a point seems at a deep conceptual level to be a sequential process. The survey results mirror what I believe is the case with the human cognitive pyramid: the number of simultaneously performed tasks seems to increase dramatically toward the sensory base.

Clever information-processing assistants that can see, hear, and think a little will be a liberating and welcome change from today's machines. Advertising notwithstanding, current computers are dumb and unfriendly: witness the inexcusable 10-inch-thick manuals that often accompany professional word-processing programs. Instead of typing, users of multiprocessors will be able merely to issue verbal commands and show graphs or text to the machine. More important, users will be able to employ a more natural and less precise idiom since, by virtue of their increased intelligence, these new computers will be more forgiving than their allegedly friendly predecessors.

Possible uses of multiprocessor systems beyond speech recognition and machine vision include:

☐ Automated clerical assistants.

☐ Tutors that can understand students' progress and can ask questions to correct weaknesses.

☐ More intelligent retrieval systems that can understand what information the user wants—in finance, law, medicine, government, and other fields.

☐ Knowledge-based systems that know a great deal—and can help users—in narrow areas of expertise such as investing and medical specialties.

☐ Robots that can perceive their environments and act appropriately—perhaps to do hazardous work such as cleaning up toxic waste or jobs requiring great precision.

☐ Monitors that watch or listen to numerous events and flag the most important for the human user to review.

Architectures

Multiprocessor systems should not be confused with the distributed computer networks that are already becoming the backbone of office automation. In these networks, relatively slow local or long-haul connections generally link a number of geographically remote machines, communicating information at a few hundred to a few hundred thousand characters per second. Multiprocessor systems are in one location and communicate data among their processors at a few million to a few hundred million

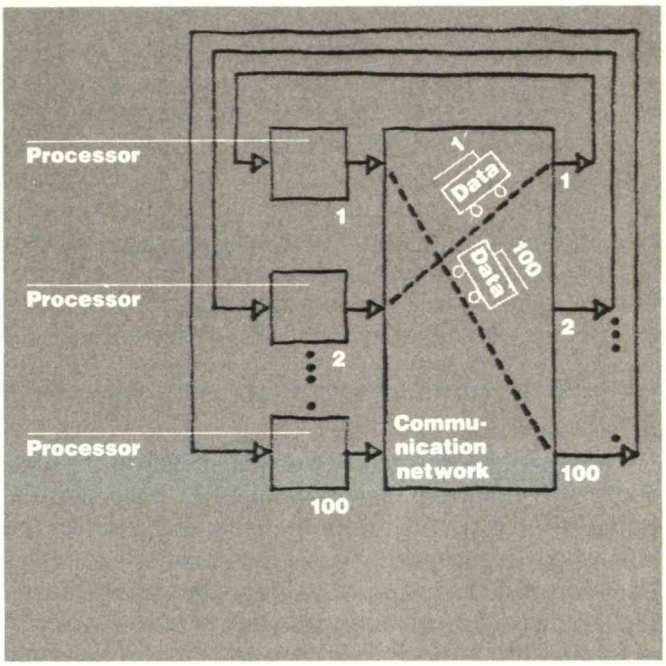
DIAGRAMS: OMNIGRAPHICS

characters per second. More important, a distributed system is a collection of predominantly autonomous machines, each controlled by its own user but able to communicate with other computers—such as in sending electronic mail or requesting data. By contrast, in multiprocessor systems, many processors work under a central control on a single problem. In a loose analogy, a distributed network is like a society of communicating individuals and organizations, while a multiprocessor is like the aggregate of neurons in a single human brain.

Today research groups in some 50 universities, industrial research laboratories, and start-up companies around the world are experimenting with multiprocessors. While it is hard to classify these machines precisely, I will describe a few of them to convey a flavor of the different possible architectures and the problems associated with each.

A typical "dataflow" multiprocessor is the Tagged Token Dataflow Machine that Professor Arvind and his group are building at the M.I.T. Laboratory for Computer Science (LCS). Machines of this sort are relatively coarse-grained—our machine at LCS has 50 to 100 processors. A communication network like a railroad switchyard connects these processors. Every time a processor produces a unit of data, it incorporates a "tag"—information on where the data should be sent and how they should be used. The "switchyard" uses part of these tags to route the data to another processor. Once there, the data wait for any related data that may be required for the next computation. When all the required data have arrived, the new processor acts upon them, following procedures designated by the tags. This processor sends the results—new data, with new tags—back to the network, where the whole process repeats itself. In a properly working dataflow machine, almost all the processors should be humming away, issuing tagged data that are switched to other processors through the network.

In a "tagged token dataflow" machine, processors issue data with "tags." Like a railroad switchyard, the communication network uses part of each tag to route data to the processor that will perform the next operation. Another part of the tag tells this new processor what to do. In a properly working dataflow machine, almost all of the processors should be continually humming away, issuing tagged data that are switched to other processors through the communication network.



Invented at the M.I.T. Artificial Intelligence Laboratory and under construction by Thinking Machines Corp., the Connection Machine typifies another approach. The first model of this machine consists of 65,536 fine-grained processors connected to one another in three ways. First, the processors are arranged on a grid, where each communicates with its neighbors on four sides—the "North," "South," "East," and "West." Second, the "broadcast network," a slower communication line, passes through every processor and links all of them to a central control computer. Finally, a "16-dimen-

SOME MULTIPROCESSOR PROJECTS

UNIVERSITIES

California Institute of Technology
Columbia University
Illinois University
Manchester University
Massachusetts Institute of Technology
New York University
Purdue University
University of California, Berkeley
University of London
University of Maryland
University of North Carolina
University of Texas
University of Utah
Washington University

COMPANIES

Alliant
ATT
Axiom
BBN
Control Data
Cray
Culler Scientific
Denelcor
Encore
ETL (Japan)
Flexible Computer
Goodyear
Harris
ICOT (Japan)
Intel
IBM
MCC
Myrias
NEC (Japan)
Sequent
Thinking Machines

sional-hypercube network" also connects the processors.

To visualize such a hypercube, start with a two-dimensional "hypercube"—an ordinary square. A square has four corners, or vertices. To make a three-dimensional hypercube (i.e., an ordinary cube), place one square in front of another and connect the corresponding vertices of the two squares with lines that form four new edges. Now suppose there is a processor at each vertex and a communication line along each edge. That makes eight (2^3) processors in all. Any of these eight processors can communicate with any other by sending a signal through no more than three communication lines.

Now repeat the geometric construction process using two three-dimensional cubes. In other words, juxtapose the two cubes diagonally and connect the corresponding vertices with eight new edges (diagonal lines). The result, which can be drawn in ordinary three-dimensional space, is what we will call a four-dimensional hypercube. It, too, can be thought of as having a processor at each vertex and a communication line along each edge. But since it is composed of two three-dimensional cubes, it has twice as many processors—16 (or 2^4). Any processor can communicate with another by sending a signal through no more than four communication lines.

Similarly, you can connect two 4-dimensional hypercubes to get a 5-dimensional hypercube, and you can extend the process to as many dimensions as you wish. A 16-dimensional hypercube has 65,536 (or 2^{16}) processors, and each processor can communicate with any other by sending a signal through at most 16 communication lines. The hypercube network is used in the Connection Machine and other multiprocessors because it allows many processors to communicate relatively quickly using a reasonable number of wires. The alternative of connecting every processor to every other would result in an impossible wiring task, with over 2 billion wires.

The Connection Machine is a fine-grained multiprocessor. Each processor is quite small—having around a thousandth the complexity of a processor in a dataflow machine such as Arvind's—and is capable of processing fewer instructions on smaller chunks of data. The central computer initially feeds the processors with data through the broadcast network. The processors can then repeatedly compute and send data to their North-South-East-West neighbors, to their neighbors on the 16-dimensional hypercube, or back to the central computer.

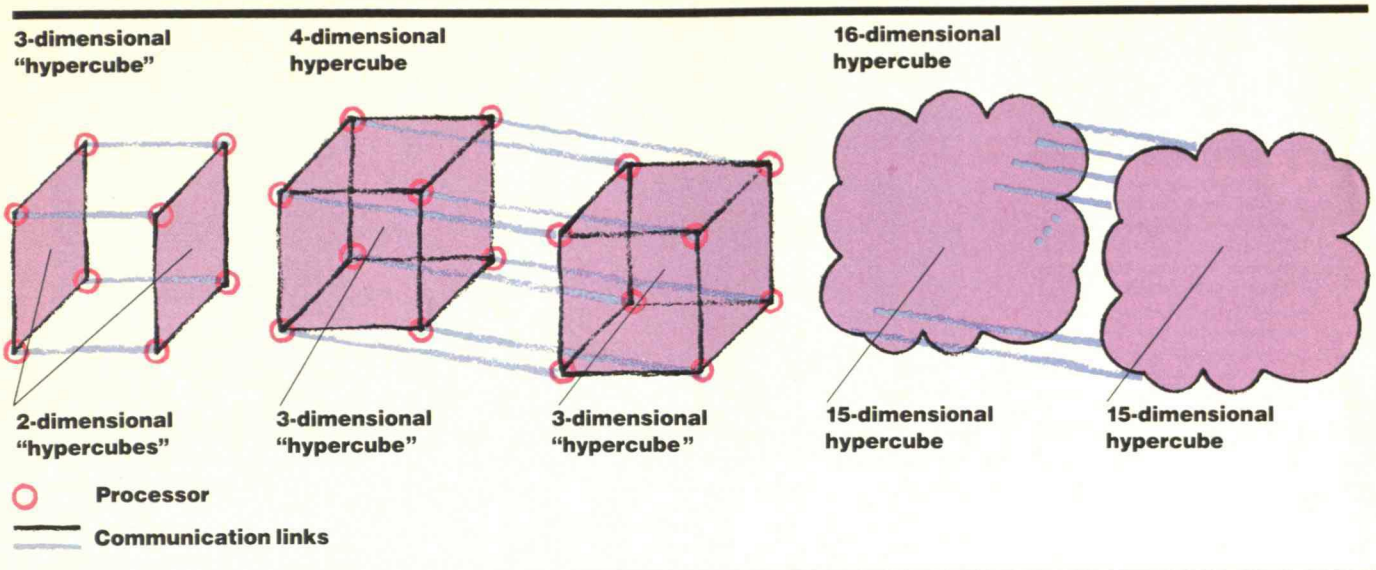
Machines like this will probably be especially useful in sensory applications, where fine-grained processors and adjacent communications are important. For example, a two-dimensional "retina" could be made to recognize lines or edges when adjacent cells—i.e., adjacent processors—register a common light value along a particular direction. To recognize such lines or edges, processors would communicate on the North-South, East-West grid. After identifying such lines and edges, the multiprocessor system could use them to build an abstract, higher-level model of what the retina "sees." Building such a model could involve communication among more distant processors on the hypercube.

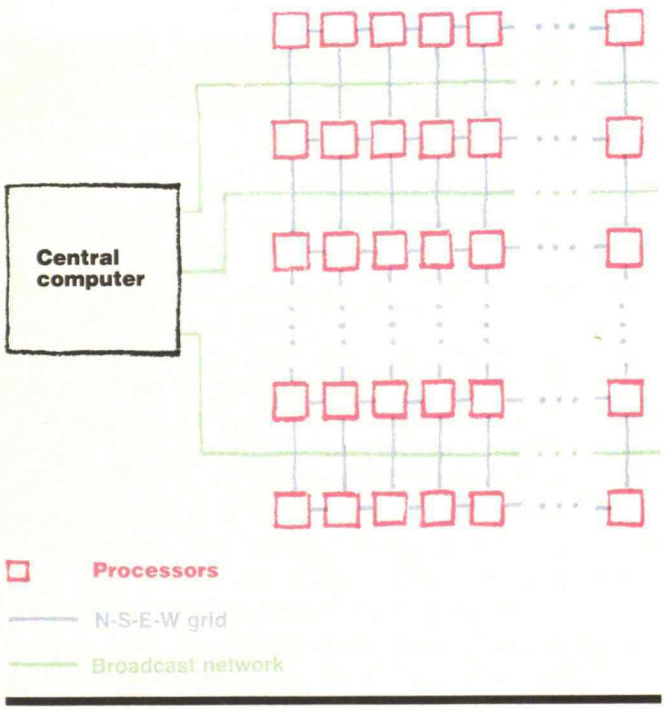
Perhaps the most common multiprocessor architecture uses a "shared memory" to communicate information among processors. In this scheme, each processor resembles a conventional computer with a local memory and peripheral devices such as sensors, printers, and screens. A memory common to all processors serves as a blackboard: any processor can write information on it, which any other processor can subsequently read. If processor A wishes to communicate with processor B, it writes its message on the shared memory, and B reads it. However, while the writing and reading is going on, no other processors can communicate. The common memory thus becomes a bottleneck. To compensate for this limitation, the shared memory is typically very fast and is often augmented with auxiliary wiring so that the system can accommodate several tens to several hundreds of communicating processors.

Shared-memory architectures are relatively inexpensive and represent a conservative approach, since they permit a gradual transition from today's single-processor, single-memory computers to multiprocessor systems. Companies such as Flexible Computer Corp. of Dallas use machines with this kind of architecture, marketing them for aerospace and scientific applications.

Programming Multiprocessors

There are as many different approaches to programming multiprocessor systems as there are to organizing a multiprocessor architecture. In the "functional-language" approach, the programmer uses instructions that behave like mathematical functions—taking particular inputs and producing out-





In the Connection Machine, numerous processors are connected to one another in three ways.

First, a relatively slow "broadcast network" links a central computer to every processor. Second, the processors are arranged on a "North-South-East-West" (N-S-E-W) grid. Each communicates with its neighbors on four sides—"North," "South," "East," and "West." Finally, a "16-dimensional hypercube" (not indicated here) connects the processors.

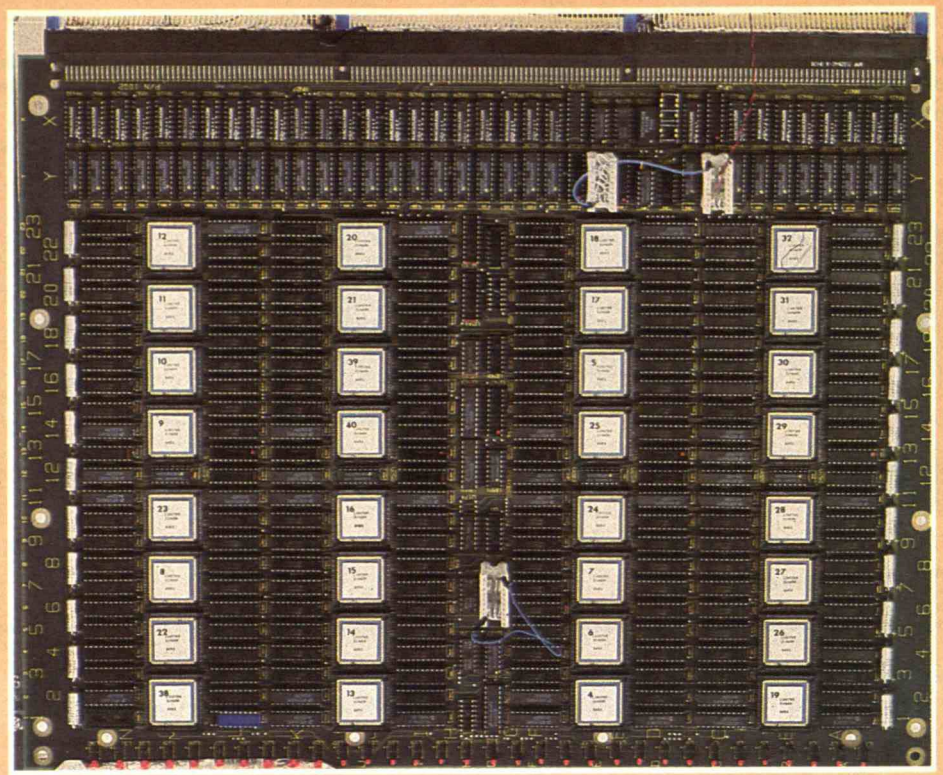
Top: Illustration of the geometric principle behind the hypercube (explained on page 50). The hypercube allows each processor to communicate with any other through no more than 16 communication lines. Machines like this with numerous, relatively simple processors and adjacent communications might be especially useful in sensory applications. For example, such a machine could work like a simple retina.

puts. One elementary function, PROD, might find the product of inputs. For example, PROD (3,10,4,5) would have four inputs and one output—in this case, $3 \times 10 \times 4 \times 5$, or 600. Another function, SQ, might square its input if it is between 1 and 1,000 but leave it unchanged if it is outside this range. Thus, SQ (5) would be 25, and SQ (2,000) would be 2,000.

Of course, functional languages use functions to perform operations that are far more complex and useful than these simple examples suggest. More important, functional languages allow basic functions to be combined into aggregates, in which the outputs of some functions become inputs to others. These aggregates themselves behave like functions, in that they take inputs and produce outputs. Thus, they can be combined into yet more complex aggregates, which also behave like functions. Functional programs can be thought of as huge diagrams of interconnected functions, in which the outputs of one function are inputs to another, until they produce one or more final results.

Significantly, functional programs like these have only inputs and outputs and no "side effects." Side effects are operations that store certain results in memory "on the side" while a program processes inputs to produce outputs. Thus, a procedure may take an input and square it to produce the output, but may simultaneously increase a running total in memory by the same amount as the output. Completing some later step in the program will require referring to this running total. Today's languages encourage the use of side effects, and nearly all practical programs employ this device.

Functional languages may be harder to use, but



One of the circuit boards from the Connection Machine, a multiprocessor system developed by Danny Hillis of Thinking Machines Corp. of Cambridge, Mass. Each of the 32 chips plugged into the board contains 16 processors. Thus, the board has 512 processors. The Connection Machine will have 65,536 processors in all.

they have several advantages. They result in programs with cleaner structures, precisely because there are no confusing side effects to keep track of. Moreover, one aggregate function can easily be replaced by another that produces the same outputs from given inputs, but that has a simpler internal structure and is therefore faster to execute. With the functional approach, it is easier to verify that large programs operate correctly, a task that is often difficult with today's programs. And functional programming makes it easier to specify a program—to give a precise, brief description of everything it is supposed to do before the programmer starts to write it.

In the functional-language approach, the programmer can be fairly oblivious to the physical structure of the machine and is liberated from the task of assigning operations to particular processors. Instead, another program, a multiprocessor compiler, automatically splits the primary program into concurrent subprograms for different processors and specifies the necessary intercommunications. This permits the programmer to focus on the functions to be done rather than on coordinating individual computations. However, this approach may lead to programs that are inefficient to execute. The compilers that establish which operations should run concurrently may miss shortcuts and opportunities that programmers could specify.

In what I would call the "concurrency-extension" approach to programming, a minimal set of instructions added to conventional computer languages such as Fortran, C, or Lisp enables the programmer to specify which processes should run concurrently. Extended languages of this sort have names like Pardo (parallel do) Fortran, Concurrent C, and MultiLisp. Programs written with this approach are generally efficient to execute because programmers can use their ingenuity in specifying which operations should run concurrently. But coordinating large numbers of processors may take the programmer a lot of time. Shared-memory architects often use concurrency extension because it is similar to today's single-processor languages, involving only one or two new instructions.

To get a clearer idea of how multiprocessor programs work, consider a very simple problem. Let a, b, c, and d be any four numbers, and suppose you want to calculate ac + ad + bc + bd. (As in customary algebraic notation, ac indicates the product of a and c.) Assume furthermore that each processor can handle only two numbers at a time and that it takes one microsecond for addition (+) and five microseconds for multiplication (×).

A conventional single-processor computer would carry out the necessary additions and multiplications sequentially. If T_1, T_2, and so on are intermediate results that need to be operated on further to produce the final result, the calculation might be done this way:

PHOTOGRAPH: THINKING MACHINES



The author at M.I.T.'s Multiprocessor Emulation Facility, where some 50 to 100 machines can be connected in different configurations by high-speed switches. This "computational sandbox" makes it possible to simulate multiprocessor designs inexpensively. Before constructing a 1,000-processor "retina," a researcher could use the facility to emulate the architecture, program it, test it, and make improvements.

Sequential Computations	*Time (microseconds)*
$T_1 = a \times c$	5
$T_2 = a \times d$	5
$T_3 = b \times c$	5
$T_4 = b \times d$	5
$T_5 = T_1 + T_2$	1
$T_6 = T_3 + T_4$	1
Answer $= T_5 + T_6$	1
	23 *Total*

The total time to perform the computation this way is 23 microseconds.

In a multiprocessor system programmed in a functional language, you need to break the problem down into a set of elementary functions and directions for combining them. Let "SUM" be the addition function—the output of SUM (2,5,7) is the sum 2+5+7, or 14. Let "PROD" be the multiplication function—the output of PROD (3,7) is the product 3×7, or 21. The process of finding ac + ad + bc + bd can be expressed in functional terms as:

SUM (PROD (a,c), PROD (a,d), PROD (b,c), PROD (b,d))

Given this functional expression, the compiler might automatically apportion the calculation to several processors, as shown below, where concurrent operations are on the same line:

Concurrent Computations	*Time (microseconds)*
$T_1 = a \times c \quad T_2 = a \times d \quad T_3 = b \times c \quad T_4 = b \times d$	5
$T_5 = T_1 + T_2 \quad T_6 = T_3 + T_4$	1
Answer $= T_5 + T_6$	1
	7 *Total*

Doing this calculation with four processors operating concurrently takes only 7 microseconds—practically a third the time it takes with only one processor.

In a language where the programmer can specify concurrency explicitly, you might do the operation another way. If you recognize the algebraic identity

$$ac + ad + bc + bd = (a + b)(c + d)$$

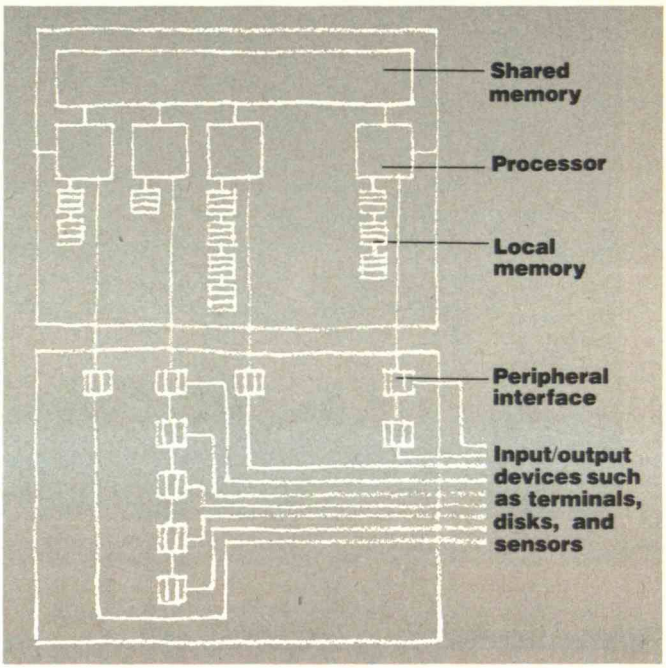
you can write the following:

Concurrent Computations	*Time (microseconds)*
Do concurrently ($T_1 = a + b$, $T_2 = c + d$)	1
Answer $= T_1 \times T_2$	5
	6 *Total*

This would take only 6 microseconds to execute and would require only two processors—the most effi-

PHOTOGRAPH: FRANK SITEMAN

Shared-memory architectures such as this permit a gradual transition from today's single-processor computers to multiprocessor systems. Each processor resembles a conventional computer with a local memory and peripheral devices such as sensors and printers. A common memory serves as a blackboard: any processor can write information on it, which any other processor can then read. Shared-memory machines are already marketed for aerospace and scientific applications.



cient calculation yet in terms of time and computer hardware.

Proponents of the functional approach would argue that the compiler spares programmers the clerical work of deciding which operations to do concurrently. Proponents of allowing the programmer to specify concurrency explicitly would counter that allowing the programmer to specify concurrent calculations saves computing time. Advocates of the functional language approach might respond that it could achieve the same computing efficiency if the programmer specified in the first place:

Answer = PROD (SUM (a,b), SUM (c,d))

Researchers will undoubtedly continue to debate the key question of how work should be apportioned between automatic compilers and human programmers.

Yet another programming approach is based on the belief that we will be able to run today's single-processor programs on tomorrow's multiprocessors. Some computer scientists are attempting to achieve this goal by developing so-called "unraveling compilers" that take as input a conventional Fortran program and generate as their output an equivalent program for a particular multiprocessor. This approach may prove feasible for small multiprocessors but not for larger machines, since the structure of today's programs is inextricably bound to the single processors that we use. To expect that efficient multiprocessor programs can be automatically extracted from single-processor programs is tantamount to hoping that the procedures of a nineteenth-century cobbler could be automatically transformed into specifications for a modern shoe factory with thousands of workers.

To my thinking, researchers must invent a whole family of new languages for multiprocessor applications. I envision that these languages will automatically detect and handle relatively simple, lower-level tasks that can obviously be executed concurrently. But for higher level, more complex operations, these languages will permit programmers to specify explicitly what should be done concurrently and how processors should communicate. The model I have in mind is like a huge data factory, full of bins that store data, conveyor belts that transport data, and assembly lines that process data. The programmer would tune this data factory, much as industrial managers tune actual factories to optimize production.

Finally, I believe that, regardless of the method used, programming multiprocessor systems will inevitably require more effort than programming today's single-processor systems, since the programmer will have to specify and coordinate so much more.

Thinking Concurrency

Since computer science is a predominantly experimental discipline, we can best design a new multiprocessor after simulating it on a computer, where we can adjust parameters and assess performance. However, such a simulation requires a huge number of concurrent activities that cannot reasonably be modeled by a conventional, single-processor computer. Thus, we can effectively simulate a multiprocessor only on a multiprocessor—a circular situation. Such problems are typical in computer science. In this case, we take our best guess at designing an initial multiprocessor. Then we bootstrap our way up by using this machine to simulate possible new multiprocessor systems.

This is the idea behind the Multiprocessor Emulation Facility at the LCS. This facility consists of 50 to 100 machines connected by high-speed switches,

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In designing multiprocessors, we could learn from our own bodies, which handle numerous failures effectively.

which can be used to create many different configurations of interconnections. For example, we can create a North-South, East-West grid; a ring; or an eight-dimensional hypercube. We plan to use this Emulation Facility like a computational sandbox, where we can try out alternative designs for much larger and different multiprocessor systems. A researcher with a bright idea for constructing a 1,000-processor retina could use the facility to emulate that architecture, program it, test it (at a fraction of its ultimate speed and cost), and make improvements.

This multiprocessor sandbox allows us to "think concurrency." We believe that such thinking will allow us to invent richer languages and architectures than we could if we used only paper and pencil—or if we simplified multiprocessor architectures to simulate them on single-processor machines. The latter approach is as effective as trying to perceive a rich image by sliding over it a piece of paper with a peephole.

Reliability and the Swiss-Watch Syndrome

One of the drawbacks of a computer with many processors is the increased opportunity for both hardware and software malfunctions. Today's single-processor machines can run without a major hardware fault for up to a few thousand hours. Software errors can take place within tens or hundreds of hours. At such rates, a 1,000-processor system would have a hardware failure every few hours and a software failure every few minutes. We cannot allow a single failure to cause an entire multiprocessor system to crash.

Some multiprocessor designers try to incorporate error detection and correction into their architectures. For example, the processors may check their own soundness or that of other processors by running small test procedures. While the program is being executed, the system assigns computations only to those processors that are in good running order. Such a multiprocessor is analogous to a factory in which management assigns the jobs of sick employees to healthy ones.

We still have little practical experience in detecting and correcting errors in large computer systems, and some researchers are postponing work on this problem until they solve what they feel are more pressing architectural and programming issues. I believe this is a misguided approach, since reliability may turn out to be pivotal to the evolution of multiprocessors. Today nearly all of our computers and their programs are like precision watches—one small flaw on one small gear and the whole mechanism grinds to a stop. In designing multiprocessors, we could learn a great deal from our own bodies, which can handle numerous failures effectively.

I believe we can accomplish this only through radical architectural innovations based on notions of "continuity" and "mushiness," so that small changes in one part of the system cause only small changes in every other part. In imitation of the human nervous system, we might compromise between digital and analog modes of encoding data. Most computers record information digitally in a collection of on or off signals; the sound-wave forms on conventional LP records are analog. Digital recording can be as accurate as required, but a little damage can result in catastrophic change in the recorded data. Comparable damage to an analog recording is relatively minor: a slightly scratched record still reproduces the song. To incorporate the benefits of digital accuracy and analog tolerance to faults, information could be encoded as standard electrical pulses that have the same size but are emitted at different rates. The rates could vary continuously, so that a small error in one signal or in the system would only cause a small distortion in the output. But such "mushy" systems may have to wait for yet another revolution beyond the precision-oriented multiprocessors that we are working on today.

The Global Race

Only a few U.S. research laboratories pursued multiprocessing until 1980, when Japan announced its Fifth Generation Computer Project. That effort, involving some $1 billion over 10 years, aspires to tackle AI problems—to translate automatically between Japanese and English and devise programs that embody human expertise. To achieve these ambitious goals, the Japanese are pursuing multiprocessor machines intensely. The Institute for New Generation Computer Technology (ICOT) spearheads this research and apportions it to participating companies. Having established an advanced electronics infrastructure, the Japanese are now trying to become familiar with the looser, more tentative research approach required for AI.

The United States has acted—or reacted—in sev-

By skewing research toward immediate military objectives, the U.S. may cede leadership to Japan.

eral ways. The Microelectronics and Computer Technology Corp. (MCC), a consortium of leading U.S. semiconductor and computer firms, is financing and sharing research of common interest to all the firms. Multiprocessor systems are the most important of MCC's four research areas.

On a more traditional front, the Department of Defense's Advanced Research Projects Agency (DARPA) has launched the Strategic Computing Program. Multiprocessor research receives a major part of the program's $150 million annual budget. Also, U.S. venture capitalists have begun to finance companies that build multiprocessors. At this writing, there are over ten such start-ups, with about half still doing R&D and the other half starting to sell products. Big companies such as IBM have cautiously begun advanced research in this area, too.

Europe has launched at least two multiprocessor programs. The British Alvey effort, with fewer funds than Japan's, focuses primarily on forefront computer research and on the kind of software necessary for AI applications. The European Economic Community (EEC) has launched ESPRIT, a program with funding comparable to the Japanese effort. ESPRIT spans many areas of information technology and involves many countries.

If Japan reaches its immediate objectives, it may indeed approach its ultimate stated goal—world supremacy in information technology. Even if it does not reach this goal, the country may gain substantial benefits. For example, the Japanese could develop products with capabilities for vision, speech, and intelligence—such as a voice-controlled television set or a car that can diagnose its malfunctions.

On the other hand, the United States stands a good chance of retaining its leadership in information technology if it pursues the multiprocessor challenge. We need only use the proven mechanisms of DARPA-funded programs and venture capital, which have been responsible for the landmark innovations in information technology. DARPA-funded research gave rise to time-shared computers, artificial intelligence, expert systems, and computer networks, while firms funded by venture capital developed the microprocessor and home computer.

The relative U.S. disadvantage in production—lacking highly organized, coherent teams of workers that follow precise objectives—is our primary advantage in innovation. Forefront research in computer science likes a flexible, experimental, exploratory approach and does not react well to detailed management or preset objectives.

However, several recent, disturbing trends could impair just this flexible approach and hence U.S. success. The government has become increasingly preoccupied with possible leaks of research to military adversaries and commercial competitors. The government has also begun to seek research results with more immediate military relevance, and it has instituted increasingly lengthy and bureaucratic processes for allocating funding to new projects, akin to the competitive bidding for weapons contracts. These trends reflect a well-intentioned desire to tighten the government's management of basic research. However, because of the freedom that such research requires, this trend toward increased management could do far more to damage innovation than to accomplish the intended goals. As a result, the United States could cede leadership in information technology to Japan.

The EEC effort, spread thin by the large number of participants and the inevitable political orientation of a consortium of nations, is not yet a major contender in multiprocessor technology. However, the EEC effort could surprise us because of the strength of European theoretical researchers.

Technological leadership of the information revolution is, in my opinion, ultimately linked to geopolitical strength. At the turn of this century, England and the other leaders of the industrial revolution held the reins of the world because of their industrial might and knowhow. In the forthcoming era of a service-dominated economy, information will undoubtedly play a progressively greater role in all facets of our professional and personal lives. The nations that master this new revolution will exert leadership in the economic and geopolitical arenas.

We are not yet sure whether multiprocessors will offer as revolutionary a jump as we envision in the use of computers. Nor are we certain whether they will help us move much closer to the elusive and seductive goal of greater machine intelligence. The prospects look good, and the emotional temperature is high with expectation. But we must wait for the results of many experiments now in progress before we can give a more unbiased and factual assessment. The answers may well come within five years. Meanwhile, we can continue to dream, hope, and work toward these new and exciting prospects in information technology. □

The Hidden Liability of Hazardous-Waste Cleanup

BY GORDON F. BLOOM

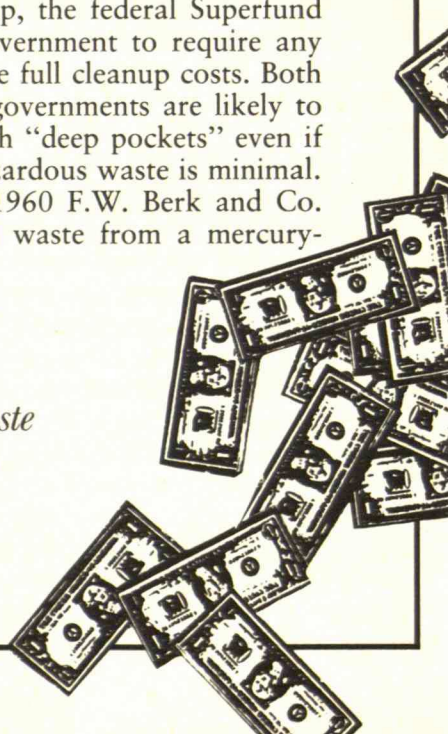
MANY people think that hazardous waste is a major problem only for the chemical and petroleum industries and a few towns with leaking landfills. Nothing could be further from the truth. The fallout from ever more stringent regulations on the disposal of hazardous waste, and the costs of cleaning up the many wastes improperly disposed of in the past, will affect the lives of every U.S. citizen and the future of every business. The prices of consumer goods will rise, small firms may go out of business, the structure of industries may change, and companies will have to redesign their products to produce less waste.

A few examples will suggest the widespread ramifications of regulations on hazardous waste. Suppose a savings bank grants a mortgage loan to a developer to build a shopping center. The center operates successfully until one day the owner receives a notice informing him that the center has been built on land with buried oil tanks that are now leaking and polluting a nearby water source. The state orders the owner to clean up the waste under the terms of the state Superfund law. Since the owner cannot comply with the state order and also afford to pay interest and principal on his mortgage, he defaults. A good loan has suddenly become a bad loan.

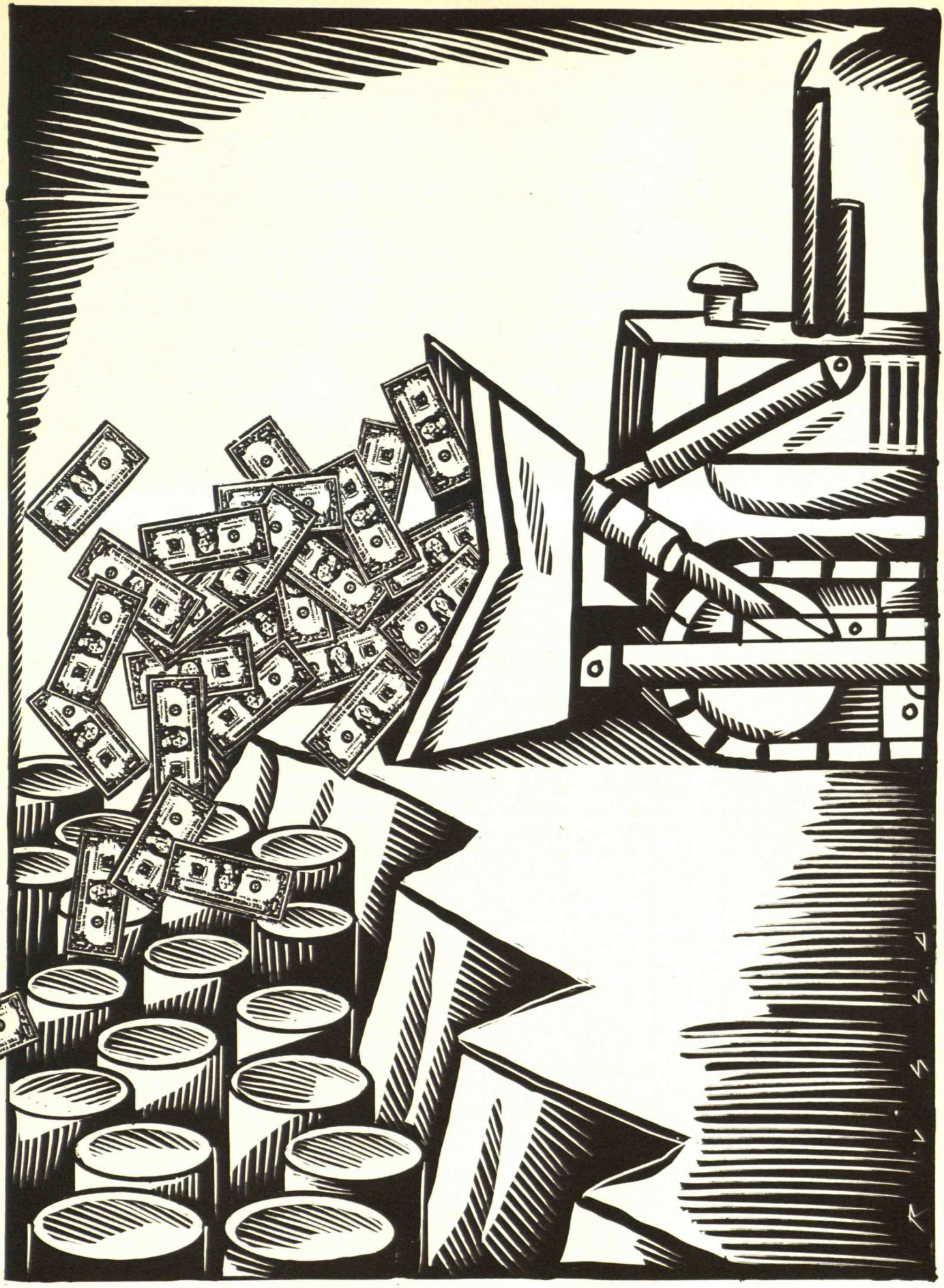
In Kansas City, the Environmental Protection Agency (EPA) is seeking to clean up a five-acre toxic-waste dump that has leached into the area's groundwater and from there into the Missouri River. The EPA originally sued the company that operated the dump, but when the operator could not pay the cleanup costs, the agency sued four firms that had allegedly deposited waste at the dump: Armco, FMC Corp., Western Electric Co., and IBM. Even though about 300 companies had used the dump, the federal Superfund law allows the government to require any one firm to pay the full cleanup costs. Both federal and state governments are likely to sue companies with "deep pockets" even if their output of hazardous waste is minimal.

From 1929 to 1960 F.W. Berk and Co. dumped untreated waste from a mercury-

New regulations on the disposal and cleanup of hazardous waste promise to have far-reaching effects on American business.



ILLUSTRATIONS: ANTHONY RUSSO



Landowners are liable for cleanup costs even if they had nothing to do with disposing of the waste.

processing plant into a New Jersey creek. In 1960 the firm sold its assets to the Wood Ridge Chemical Co., a subsidiary of the Velsicol Chemical Corp. Berk went out of business and Wood Ridge continued to dump the waste. In 1968 Velsicol sold the capital stock of Wood Ridge to Ventron Corp., which allowed the subsidiary to discharge waste until 1974. In 1978, the N.J. Department of Environmental Protection sued the various firms to force a cleanup of the creek. The New Jersey Supreme Court ruled that since Berk and Wood Ridge were no longer in business, the court could "pierce the corporate veil" and hold both Velsicol and Ventron retroactively liable for the acts of Wood Ridge.

Despite these provisions, the firms that generate hazardous waste will be most responsible for cleaning it up. These include producers of primary metals, inorganic chemicals, and organic chemicals such as pesticides; petroleum refiners; electroplating companies; textile dyeing and finishing firms; leather-tanning firms; battery makers; and semiconductor companies, once thought to be clean but now recognized as significant polluters. These firms now face enormous potential liabilities from leaking landfills even though they may have complied with all regulations in effect when they disposed of the waste.

But even firms that do not themselves produce hazardous waste may be liable for the chemicals found on their land, and for those that a newly acquired subsidiary produced in the distant past, according to federal and state Superfund laws. Moreover, tighter federal restrictions on the disposal of even half a barrel of hazardous waste a month mean that many more businesses than ever before will have to account for their waste.

New Regulations Take Effect

Americans produce about 255 to 275 million metric tons of regulated hazardous waste each year—about one ton per person. (This total does not include hazardous household products, whose disposal now goes unregulated.) Most of this waste is discarded on land. Europeans, who do not have access to as much vacant land as Americans, burn about 50 percent of their hazardous waste; Americans burn only about 15 percent. The United States is beginning to pay a high price for this pattern: the EPA estimates that there are 33,000 to 50,000 improper waste dumps in the nation, many of which are now leaking into wells and aquifers. Yet the full extent of the problem is unknown, since some of the dumps are as much as 100 years old and no one knows where they all are, what is in them, and what chemical reactions might have occurred to turn harmless substances into toxic ones. Nor does anyone know how much cleaning up these dumps will cost: the Office of Technology Assessment estimates that dealing with the most critical 10,000 sites will cost $100 billion.

Two federal statutes are of primary importance in regulating the disposal of hazardous waste. The Resource Conservation and Recovery Act (RCRA) of 1976 requires that anyone treating, storing, or disposing of hazardous waste obtain a permit from the EPA. The agency is supposed to grant permits only to firms that show that they know how to operate a landfill or other disposal facility, have enough financial backing and insurance, and have the expertise to monitor the facility. In reality, the EPA has had to relax these requirements because so few firms can meet them. Still, the agency can impose hefty fines on firms that violate the act, and even hold individuals criminally liable for disposing of waste improperly. Congress recently extended the RCRA provisions to apply to anyone who produces at least 220 pounds of waste a month—or about half a 55-gallon drum. This brings many small businesses not previously regulated under the act's purview, including even local dry-cleaning firms, for example.

The recent amendments to RCRA also set forth a fundamental change in national policy regarding how to dispose of wastes. When Congress passed the original bill, land disposal was considered safe. However, the new amendments forbid the dumping of many of the most dangerous wastes, require firms to show that they have no other means of disposal when they do dispose of wastes in landfills, and require them to treat the wastes to the fullest extent possible. For example, the act largely prohibits land disposal of arsenic, chromium, and other highly toxic liquid wastes beginning in July 1987, outlaws most land disposal of spent solvents and dioxins beginning in November 1986, and prohibits most underground injection of these wastes by 1988.

The second piece of hazardous-waste legislation—the 1980 Comprehensive Environmental Response,

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Compensation and Liability Act (CERCLA), known as Superfund—gives the EPA broad authority to take action to clean up hazardous-waste sites. The original act established a $1.6 billion fund, financed jointly by industry and the federal government, to begin cleanup operations for the most dangerous dumps. Congress is now debating extension of the act and increases in its funding. The EPA can require those it deems responsible for a site to clean it up, or the agency can take action itself using Superfund money or funds it recovers by suing those it deems responsible. It is the latter provision that makes the law so significant for so many businesses.

Superfund allows the EPA to hold four categories of persons liable for cleanup costs: present owners and operators of a disposal facility, persons who owned and operated a facility at any time in the past when hazardous substances were discarded there, any person who arranged for disposal or treatment of hazardous waste at a site, and any person who transported wastes to a site. There is considerable ambiguity in these provisions, but the EPA is administering them according to three principles. First, there is strict liability. That is, owners of land from which hazardous substances are released are liable even if they had nothing to do with disposing of the waste. Moreover, firms that deliver waste to a reputable contractor for transport to a licensed landfill may be liable if the landfill leaks.

Second, liability is "joint and several," meaning that even if a firm has been responsible for dumping only a small portion of the waste at a site, the EPA can require it to pay all cleanup costs. Third, the act is retroactive, apparently without limit: if the EPA can prove that a firm disposed of waste at a site any time in the past, the company can be held liable for cleanup now, as long as the EPA brings suit within three years after discovering the problem. The older the firm, the more likely it is to be subject to such liabilities. Monsanto recently agreed to contribute to the $13 million costs of cleaning up a site where it had dumped acids more than 50 years ago.

Like RCRA, the Superfund law allows the EPA to impose civil and criminal penalties. In addition to suing for cleanup costs, the government can force firms to pay damages for injury to natural resources, and violators who fail to comply with EPA orders can be fined as much as $5,000 a day and assessed triple damages. The EPA has recently stepped up all its criminal prosecutions. However, the agency has cleaned up only a few sites so far, partly because the number of personnel available to work on the problem is limited. Therefore, some 33 states have passed their own Superfund laws allowing them to clean up dangerous dump sites and recover damages.

So far, federal laws and most state laws do not provide a mechanism for compensating people who have become sick from leaking waste dumps. Instead, individuals must bring personal-injury tort liability suits, which are very difficult to win. These people must show that a certain firm disposed of the waste, and that this particular waste caused their cancer or other disease. Proving such a case is extremely difficult because of the long latency period of many diseases, and the fact that they may be caused by a number of factors. Moreover, firms may no longer be liable if statutes of limitations expire before people realize they have become ill. Members of the U.S. House and Senate have introduced a number of bills to deal with the problem of compensating

Some courts have held company officers personally liable for cleanup costs.

toxic-waste victims, but the legislation is unlikely to be enacted in the near future. Representatives recognize that any effective remedy could open the gates to a flood of claims that could dwarf asbestos litigation and bankrupt many major industrial firms.

The Steep Costs of Pollution Liability

The costs of complying with laws on disposing of hazardous waste and paying to clean up past disposal sites can only escalate. More Love Canals will surface and authorities will discover that important water supplies have become contaminated. Public outrage will provoke even more stringent regulations. The firms involved will bear the costs initially, but the public will ultimately pay.

Cleanup costs are already huge. Cleaning up the notorious landfill in Tyngsborough, Mass., will cost about $1.6 billion, for example. Moreover, no cleanup is ever final. Although the EPA has cited the Butler mine tunnel in Pittston, Pa., as one of six sites it has totally cleaned up under Superfund, millions of gallons of polluted water poured from the tunnel when rains from Hurricane Gloria flooded it in September 1985.

Legal costs will also be high under Superfund, as firms that the EPA sues will in turn sue other companies that have also dumped waste at a site. Firms will also have to pay the administrative costs of complying with federal and state regulations on disposing of toxic waste, and contribute to state and national Superfunds.

The EPA has estimated that efforts to comply just with the recent RCRA amendments will cost U.S. companies $10 billion to $20 billion each year. Firms will have to install sophisticated new equipment to treat their wastes, and makers of pesticides, batteries, resins, and other common products may have to change their formulas and adopt new ways of making such products to cut down on the amount of hazardous waste produced. Such efforts to reduce society's risk are important, but they will require large amounts of capital. Banks may be reluctant to lend to firms that are threatened with major liability for past dumping practices.

Companies that continue to use landfills will also face serious difficulties. Although land disposal now costs only one-eighth as much as incineration, dumping will become more expensive as landfill owners have to install new equipment to make their sites more secure, monitor the results, and pay steep insurance premiums. Moreover, the EPA has recently estimated that two-thirds of the nation's dumps have failed to qualify for permanent operating permits and must be closed. This means that firms will have to pay the costs of transporting their wastes to more distant sites. The costs of reformulating products and installing equipment to reduce wastes, as well as of properly disposing of the wastes that are produced, will be reflected in higher prices for consumer goods.

The costs of complying with hazardous-waste regulations will be most onerous for older firms in smokestack industries, such as chemicals, textiles, and iron and steel. Many of these industries are already facing severe competition from abroad, and the costs of changing their production methods will make them even more vulnerable to losing markets to imports. Because of these pressures, smaller firms may find it difficult to survive, and the tendency of a few large firms to dominate the older, capital-intensive industries may increase.

Some firms may decide to stop making products such as highly toxic chemicals, and other companies that depend on these materials may find that supplies have dried up. Companies may also be reluctant to begin making new products that result in hazardous waste because the threat of liability is too severe—much as huge awards in product-liability suits have deterred some firms from making medical equipment. Moreover, individuals may be reluctant to start up small firms that generate hazardous waste because some courts have held company officers personally liable for cleanup costs, especially if the officers are substantial stockholders.

Even firms that decide to shut down plants that have been producing hazardous substances for many years may face high unexpected costs. Cleaning up the area around a plant and disposing of contaminated equipment could prove to be very expensive. Manufacturers of tetraethyl lead, which the EPA is phasing out of use in gasoline, are facing just such a problem. Their plants are so contaminated that even the steel girders cannot be reused. Such firms could set up a reserve fund to pay the costs of eventually shutting down their plants. A regulated industry provides a precedent: the Massachusetts Department of Public Utilities is allowing Boston Edison to charge customers a small monthly fee to be used to pay for shutting down the Pilgrim nuclear power plant. However, any unregulated company



that decided to establish such a fund would be at a competitive disadvantage unless all other companies in the industry decided to follow suit.

Liability for damages from past dumping promises to create problems even for firms' internal accounting procedures. Companies that are required to pay major cleanup costs must decide whether to charge the division responsible for the waste—possibly turning a profitable division into a loser and hurting employees' morale and chances to earn incentive bonuses—or whether to set up an overhead account with contributions from all divisions. If the division that is responsible for the waste were charged, the prices of its products would more nearly reflect the true social costs of making them. However, the effects on the health of those divisions may be too severe to justify such a move.

Shareholders and creditors of public firms also have a stake in how companies decide to disclose possible liabilities from hazardous waste. Should a firm admit on its financial statements that it might eventually owe huge sums for cleanup costs? Experience with mushrooming claims from victims of asbestos poisoning makes it clear that access to such information could be essential to understanding a firm's true financial condition. Federal legislation that made it easier for individuals to bring personal-injury suits would make such disclosure especially important. Yet no company wants to admit that it might be liable and possibly influence the outcome of future claims. As hazardous-waste litigation mounts, the Financial Accounting Standards Board and the Securities and Exchange Commission may have to consider requiring firms to change their accounting procedures to include such disclosure.

Effects on Corporate Mergers and Real-Estate Deals

Pollution liability can pose major problems for firms wanting to take over other companies. Because state and federal statutes impose retroactive liability, all companies that have ever disposed of hazardous waste in landfills have a potential liability that does not appear on their balance sheets. Yet managers of a selling firm must typically certify that they know of no lawsuits pending against their company, and that they are unaware of any suits likely to be brought. However, such language provides little protection against lawsuits filed five or ten years after a company changes hands. Buyers that want to avoid future liability may decide to purchase only the assets of a firm rather than its stock, in addition to drawing up an agreement that the selling firm will assume all liabilities past, present, and future. However, this tactic may not work if the new firm simply continues the old one's business after it liquidates. In the case of product liability, courts have held that a firm that acquires the assets of another business and continues its product line assumes strict liability for defects in the products manufactured by the seller.

To protect themselves from such liability, some buyers are requiring sellers to obtain indemnity bonds and to set up escrow accounts to pay for any future damages. Buyers can also reduce their tender offer. However, no one of these devices can protect them from future risks completely. The problem is especially complex when the firm to be acquired does not seem to have engaged in any business involving hazardous waste. The buyer still cannot proceed with confidence, since a former subsidiary long since out of business may have dumped hazardous waste many years before.

These risks mean that a company can no longer rely on five years of balance sheets and operating statements before taking over another firm: it needs a genealogy of the seller's past. Sales of businesses may soon become extremely complex, with lawyers and search companies specializing in combing corporate histories for hidden pollution problems.

In real-estate deals, buyers and mortgage lenders



Insurance for pollution risks is either very expensive or no longer available.

have found it necessary to hire professionals to carefully evaluate sites for evidence of contamination. Such efforts are especially important since the EPA has repeatedly said it will sue landowners first for cleanup costs, whether or not they have contributed to hazardous-waste problems. One result of this policy is that banks that foreclose on properties can be held liable for the costs of cleaning up contamination on the land. In one recent case, a machine-tool firm defaulted on a bank loan because it had spent all its cash on cleaning up a contaminated plant site. The bank decided that it would be cheaper to loan the firm more money than to foreclose and become responsible for cleaning up the site. Arguments between buyers and sellers of property as to which party will bear the cost of environmental surveys and pollution cleanup are now commonplace. Buyers have always demanded a "good and clear" title. Now they are requiring a "clean" title as well.

The Insurance Crisis

The first reaction of most managers faced with large and unpredictable losses is to call their insurance agent. Unfortunately, this response will provide little relief in the case of hazardous-waste liability, as insurance for such risks is either extremely expensive or no longer available.

There are two types of coverage for pollution risks. The first—general comprehensive liability (GCL)—normally applies only to sudden, accidental losses. It is not intended to cover gradual, long-term contamination from seeping landfills. However, despite explicit language in the contracts stating this exclusion, courts have held insurers liable for such long-term cases of pollution. As a result, the number of pollution claims filed under GCL contracts has jumped 600 percent during the past three years, and the cost of premiums has skyrocketed.

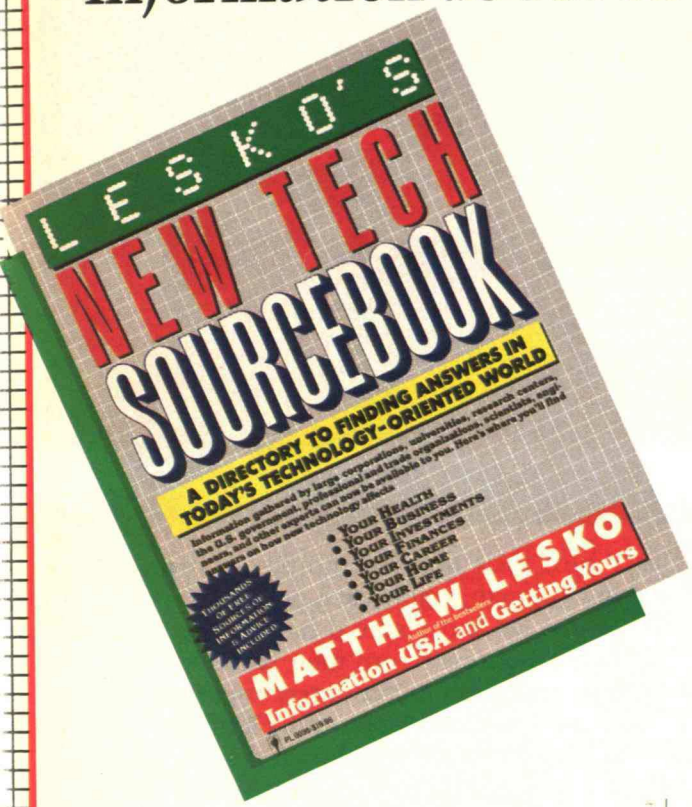
The second type of coverage—environmental impairment liability (EIL) insurance—is specifically designed to cover costs resulting from gradual contamination. However, the number of companies writing EIL insurance has dropped from 12 to 1. The remaining insurer offers only a type of self-insurance, wherein a firm can receive only as much coverage as it has paid in. The insurer assumes no risk; it simply administers the fund.

The fact that insurance companies will no longer underwrite pollution risks is an ominous sign of the magnitude of the problem facing U.S. business. Their reluctance means that communities as well as businesses will have no recourse when they are hit with huge expenses for cleaning up leaking landfills and other sources of pollution. One potential disaster exists in every community: leaking gasoline tanks. The EPA estimates that 75,000 to 100,000 tanks are leaking about 11 million gallons of gasoline each year, posing a major threat to groundwater supplies. Yet because most independent gasoline stations cannot get liability insurance, many cities and towns will have to pay to clean up such spills themselves. That will not be cheap. In Provincetown, Mass., where a 3,000-gallon gasoline leak has forced the town to reduce pumping from wells by 80 percent, cleaning up the leak and finding alternative water sources has already cost the town $3 million, and expenses may eventually exceed $25 million.

The inability of cities and towns to obtain EIL insurance will prove especially significant since they may be held liable for cleaning up municipal dumps under federal and state Superfund laws. In June

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Householders dispose of enormous amounts of toxic products daily.



1985, a New Jersey court ordered a township to pay 300 residents $5.6 million because pollutants leaching from the township landfill had contaminated their well water. The spectre of "naked" communities trying to deal with contaminated water supplies without adequate funds, because they cannot get insurance or cannot afford the steep premiums, may soon become commonplace.

Householders May Have to Clean Up Their Act

Because of problems with municipal landfills, individuals may soon find that they have to take responsibility for the hazardous waste they discard. Householders dispose of enormous amounts of potentially hazardous products daily, including drain and oven cleaners, pesticides, used batteries, and spot removers and other solvents. Although each household accounts for relatively small amounts of these dangerous materials, they become a major threat to groundwater supplies when they accumulate in municipal dumps. Although disposal of these products by individuals is now unregulated, at least ten states are considering control measures. These include an excise tax on such items that the state can use to pay to clean up wastes, and instructions on the labels that describe safe ways to dispose of the products.

As concern about leaking landfills grows, states are also likely to require consumers to pay a hefty deposit when buying hazardous products. This deposit would be refunded when consumers return the containers, much as residents of some states now must return their beverage bottles to recover their deposits. In Japan, where each person uses about 15 batteries a year and disposal has become a serious problem, consumers return their batteries to special collection centers. In this country, improper disposal of used motor oil is fast becoming a major concern. A Massachusetts study has shown that residents dispose of about 8.7 million quarts of used motor oil each year. Only 45 percent comes back to reclamation centers and gasoline stations; the rest ends up in landfills, sewers, and empty lots. Stores selling such oil may soon find that they must provide recycling facilities for the used oil.

The problem of determining how to dispose of hazardous waste safely and clean up dangerous landfills will be with us indefinitely, as our society is unlikely to reduce its dependence on chemicals to maintain the amentities of comtemporary life. Individuals, businesses, and government must focus their attention on trying to deal more effectively with the problem. Managers of waste-generating firms must make concern for environmental pollution a top priority, keeping careful track of the actions of all their divisions to prevent abuse of antipollution laws. Executives of all types of companies will need to take pollution laws into account when making marketing, production, distribution, acquisition, and real-estate decisions. Federal and state regulators should give tax breaks to firms that install new equipment designed to treat, reduce, or eliminate hazardous waste. We can no longer afford to avoid taking responsibility for the waste each of us generates. □

PHOTO: MICHAEL WEISBROT, STOCK BOSTON

we neared Santa Monica, the traffic became heavier and livelier. People clad in Op shirts, swimming suits, and flip-flops walked from side streets, corner shops, and little parking lots toward the beach. I began to feel the mounting anticipation of a crowd gathering for a space launch or a historic speech.

My friend and I parked and joined the movement ourselves. We soon caught our first glimpse of the bright blue Pacific Ocean glimmering in the afternoon sun. We took off our shoes, rolled up our pants, and walked barefoot down the great Santa Monica beach. I can still feel the keen pleasure of the sight: the huge expanse of the ocean reflecting the dazzling glow of the descending Western sun and decorated with hundreds of glorious white sailboats.

Interestingly enough, rather than looking dull by comparison, Boston looked more beautiful than ever when I returned home. As I rounded a curve on Storrow Drive, the broad expanse of the Charles River basin, with its graceful sailboats and windsurfers set against the imposing backdrop of M.I.T.'s great dome, especially caught my attention. My California vision had widened my view of these reassuringly familiar landmarks and given them a more significant context.

Mathematics is somehow similar. My recent study of invariant forms on Grassmannians, with its new scenery and perspectives, makes my other research and teaching more interesting. When I have just gained some new insight, I find more meaning in everything. As I am walking home, I notice the linden leaves overhanging the sidewalk and the sparrows fluttering in the bushes.

In *Mathematical People*, Donald Knuth, a Stanford computer scientist and recipient of the National Medal of Science, describes the wonderful time he had writing *Surreal Numbers*—a novelette based on mathematics. Efforts to write other works had cost him much time and struggle, but Knuth found himself completing *Surreal Numbers* with relative ease. He rented a hotel room in downtown Oslo, near where Ibsen wrote his plays, and followed an idyllic pattern each day. He ate a leisurely breakfast, wrote for a few hours until he came to an impasse, took a two-hour walk until a solution dawned on him, wrote for a couple more hours, ate a nice dinner, watched a little TV, did some more writing, and went off to bed. The book was finished in six days.

Knuth describes that final day: "There was a hoar frost on all of the trees, more than an inch thick. I walked around in the gardens of the king's palace . . . The midnight sky was a perfect, deep blue." □

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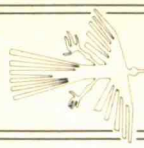
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CONTINUED FROM PAGE 5

SCIENCE WRITER'S ROLE

In "Science Writers: Angels or Devils?" (*July, page 6*), Robert C. Cowen reveals some surprising misconceptions about the scientific process. As long as science writers are unequipped to review the technical issues and make up their own minds, everything they learn is a manipulative message. They have no choice but to randomly pick one such message over another, and as a result their work is of limited use in evaluating radical discoveries. Science writers who are not accomplished scientists in their own right are probably helpful in presenting issues of average importance—but who cares about those issues?

BOGDAN MAGLICH
Princeton, N.J.

STAR WARS SOFTWARE

In "The Software for Star Wars: An Achilles Heel?" (*July, page 16*), Herbert Lin contends that a strategic defense system (SDS) must be 100 percent effective. I disagree. What we might reasonably expect of a useful SDS is not 100 percent effectiveness but a credible defense—one that will make our enemies so uncertain of success that they won't attack.

Lin also maintains that an SDS could not be fully tested in a realistic environment. But none of our current strategic weapons systems have been fully tested in such an environment, either. The fact is that modern simulation and other test techniques provide a high degree of assurance that complex weapons systems will work.

Lin is wrong in saying that a software system of 10 million written instructions is more than we can cope with. TRW has already developed software with over 1 million instructions that satisfied over 10,000 requirements. This software could detect and track ballistic missiles and perform real-time system command and control in the event of a massive nuclear attack. It has performed successfully in simulations and in live tests at Kwajelein. Furthermore, TRW did most of the work on this software between 1972 and 1979—about a decade ago. We might expect an SDS to be deployed in another decade or so. Who could say that an order-of-magnitude improvement in computer technology over two decades is too much to expect?

M. G. WENTZEL
Indian Harbour Beach, Fla.

The author responds:

First of all, President Reagan's Strategic Defense Initiative (SDI) is not a program to increase the uncertainty that an attacker might face. Rather, Reagan has held forth a vision of the future in which nuclear weapons are "rendered impotent and obsolete." The charter of the SDI Organization states that the goal is "to *eliminate* the threat of nuclear ballistic missiles."

Second, current strategic weapons can be tested much more fully than an SDS could ever be tested. A Minuteman ICBM could be tested from launch to the explosion of its primer, whose purpose is to trigger the larger nuclear explosion. Such a test would exercise nearly all of the missile's capabilities. By contrast, an SDS might be tested with great difficulty against 50 missiles; it could not possibly be tested against 100, let alone thousands.

Finally, Reader Wentzel misunderstands my discussion of the size of the computer system. The issue is that 10 million instructions suggests the complexity of the task involved. The Fletcher Commission concluded that the task of developing software for a battle-management system "far exceeds in complexity and difficulty any that has yet been accomplished in the production of civil or military software systems." No conceivable computer technology will relieve human beings of identifying and making correctly the thousands of decisions about what the software system *should* do under unforeseen conditions. If research were to result in computers capable of making decisions now made only by human beings, then perhaps we could look forward to the day when a computer could replace a human president in the Oval Office.

RUNAWAY HEALTH-CARE COSTS

In "Corporate America's Mission Impossible: Containing Health-Care Costs" (*November/December, page 40*), Regina Herzlinger criticizes corporations that seek to control health-care costs through higher employee deductibles, reviews of the use of health-care services, and health-awareness programs. She argues that corporations should instead lobby for caps on hospital costs and promote closed HMOs (health maintenance organizations), which serve only enrollees.

Unfortunately, there is little evidence that closed HMOs are efficient at containing costs and a lot of evidence that employees are resistant to joining them.

Nor will cost caps address the problem of rising health costs. The fact is that hospital use is now declining because technology has become super-efficient, encouraging shorter stays and increased outpatient and home treatment. Benefits should be revised to take advantage of this trend.

Another tactic might be to eliminate the 30 percent of hospital facilities that are not in use. Philanthropic donations should not go to underutilized hospitals for programs that are in adequate supply elsewhere. Financial institutions should be cautious about supporting the bond issues of underutilized hospitals and the stock prices of troubled proprietary hospital chains. Also, firms should exercise prudence in contracting with the new hospital "networks" that are developing locally and nationally. Few can close down their most poorly utilized members. It may be wiser to seek out hospitals with high rates of use, a full product range, and a record of innovation. Such hospitals are likely to have lower average costs.

Finally, it may be necessary to encourage employees to seek care promptly when they notice a health problem. A large part of the corporate health dollar apparently goes to employees whose diseases could have been treated relatively simply at an early stage.

TREVOR FISK
Philadelphia, Pa.

Trevor Fisk heads marketing and planning at Thomas Jefferson University Hospital in Philadelphia.

Regina Herzlinger would have done well to examine Seattle's growing co-op health service, which is apparently fulfilling medical needs at affordable rates.

A look at how Canada and northern European countries handle health care might have been worthwhile, too. All Canadians I have seen treated for an emergency health problem here have been tremendously surprised by American charges, which are twice those in Canada. Also, a neighbor of mine who had emergency hospital treatment in France reported that the cost was less than half what it would have been here.

HARRY R. POWELL
Seattle, Wash.

The author responds:
Apparent "savings" in one area of the American health-care system are frequently more than compensated for by cost increases elsewhere. For example, despite the 1984 "savings" from hospitals' occupancy rates, claims for outpatient costs are at record levels, as are hospital profits. Real savings will be achieved only by restricting the growth of the entire system, not by shuffling expenses from one part to another.

Mr. Fisk's piecemeal solutions will not produce positive results. Specifically, philanthropy accounts for roughly 1 percent of hospital revenues, and corporate philanthropy is a small fraction of that small sum. Managing corporate philanthropy will do little more than divert energy from more productive efforts. Moreover, the financial markets would not knowingly support bonds or stocks at inappropriate price levels. Our markets effectively reflect all that is known about the health-care industry at a given time.

I find it similarly hard to accept innovative hospitals with a "full product range" as the answer to the cost problem. Rather, they are a good example of its causes. Teaching hospitals have traditionally subsidized their complex research, novel clinical treatments, and educational activities by overcharging for ordinary care. A birth in a teaching hospital costs two to three times as much as one in a smaller, community hospital, for example. Hospitals that provide specialized, advanced care need to restructure their product lines and their financing. They must provide only those products for which they have distinctive competence, and find a broader base for financing their invaluable research and teaching activities.

Also, over 80 percent of health-care costs stem from illnesses caused by poor health habits such as smoking and substance abuse. The solution is not to "seek care promptly" but to change the way we lead our day-to-day lives.

In response to Mr. Powell: The health-care systems of many foreign countries are government funded. The United States, on the other hand, has been reducing the role of government in the economy. Thus, the templates offered by these other countries are not relevant.

Similarly, the co-op to which Mr. Powell refers (presumably, Puget Sound) is the product of a 1940s social ideology that has not captured the popular imagination in the United States. So while this co-op is admirable, its many accomplishments cannot be replicated widely.

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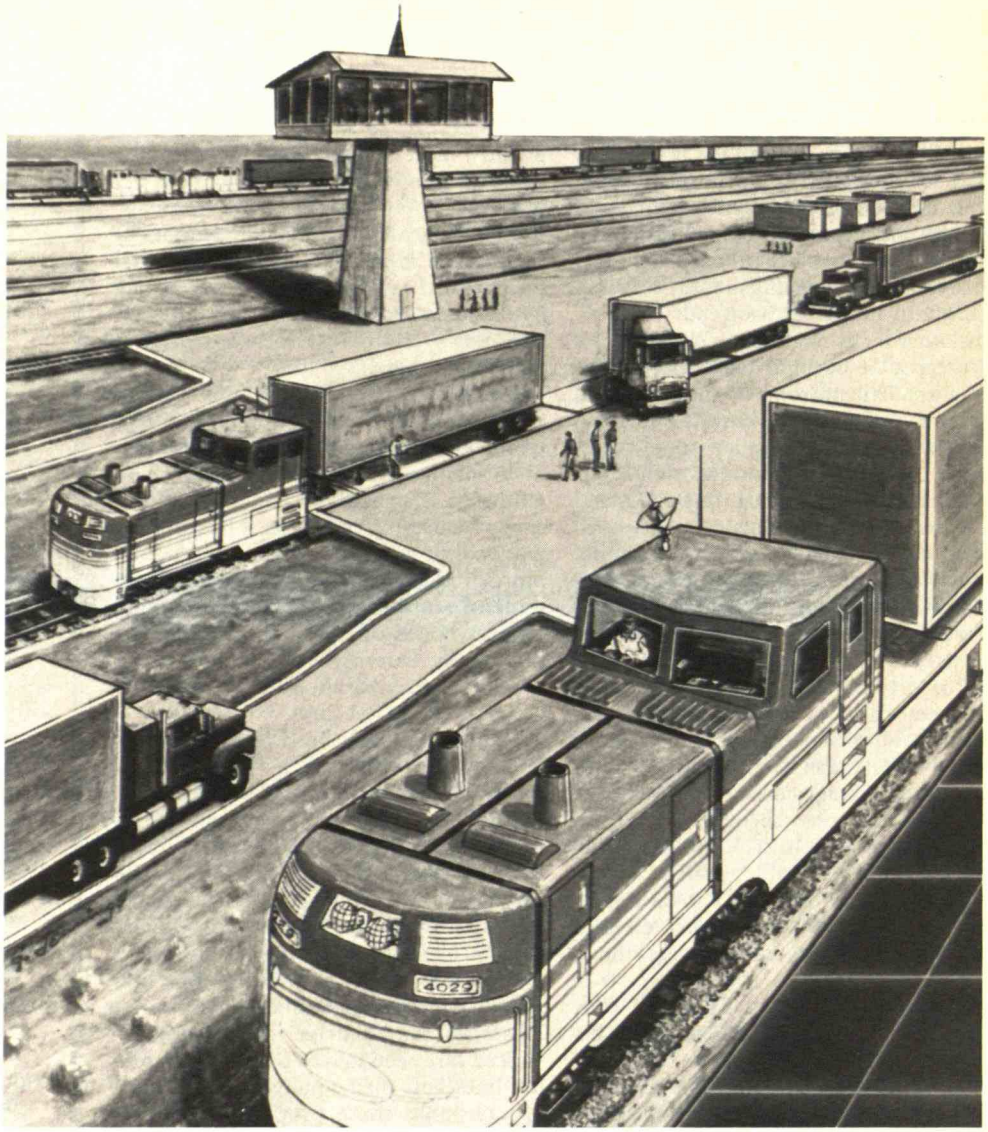
From Iron Horse to Iron Highway

The Association of American Railroads (AAR) has begun to test a new form of freight train—an "integral" train consisting of permanently coupled 28-foot-long flat cars that it says will turn old-fashioned railroads into efficient "iron highways."

The idea is to replace today's freight trains with 1,000-foot-long platforms that travel as units from origin to destination and back again. The operation will be much like today's trailer-carrying "piggyback" trains—only faster. Trucks will bring trailers loaded by shippers to central terminals, where they can quickly be loaded onto the new platforms. Trucks will also make local deliveries of the trailers at the other end.

Quick loading and unloading will be possible because 1,000-foot loading docks will be built next to the tracks at both origin and destination. Therefore, putting a trailer on a platform will be as simple as parallel-parking it—no more than five minutes' work for a skilled driver. Five drivers will be able to load 100 trailers in less than 30 minutes, and unloading will be even quicker. Reloading the train from one side might even begin before unloading is finished from the other side.

The AAR, which is now analyzing a series of proposals from would-be builders, says that the integral-train concept will also provide several other benefits:



A new form of "piggyback" rail transport will soon be tested on U.S. railroads. Strings of permanently coupled flat cars would be easily loaded and unloaded from level platforms and shuttle quickly among terminals.

☐ Control units at each end will supply power and braking to wheels located at intervals along the full length of the 1,000-foot train. Like conventional diesel engines, power units for integral trains will be easily changed at intermediate stops when necessary. But unlike today's engines, which have slow-filling fuel tanks, tomorrow's will receive fuel quickly in removable pods—24 hours' supply in ten minutes.

☐ The permanent couplings will eliminate the slack between cars that causes jarring when conventional trains start and stop—a major source of damage to cars and cargo.

☐ Without the stresses of slack and switching, the integral train can be far lighter than the cars used for today's piggyback trailers, and the weight saved can be devoted to cargo. American Air Brake Co. of Watertown, N.Y., says its integral train carrying 100 trailers would weigh 1,000 tons less than a conventional train of the same capacity.

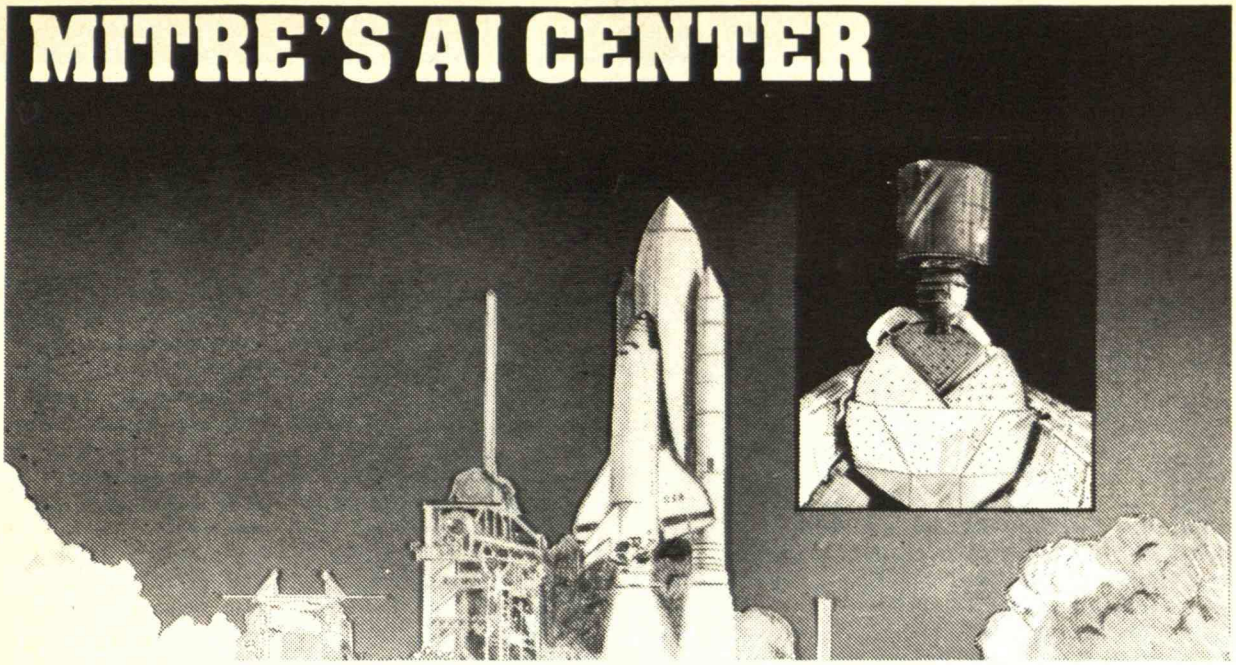
☐ When traffic demands, several 1,000-foot integral trains can be connected together, with the whole "iron highway" controlled from a single power unit at the head.

AAR plans to test of several integral-train concepts at its Pueblo, Colo., facilities by late this year, and says the first such train may be rolling across the country within 18 months. Indeed, AAR thinks 30 percent of all railroad rolling stock in the United States will be in the form of "iron highways" by 1995.

—*John Mattill* ☐

ILLUSTRATION: NEW YORK AIR BRAKE CO.

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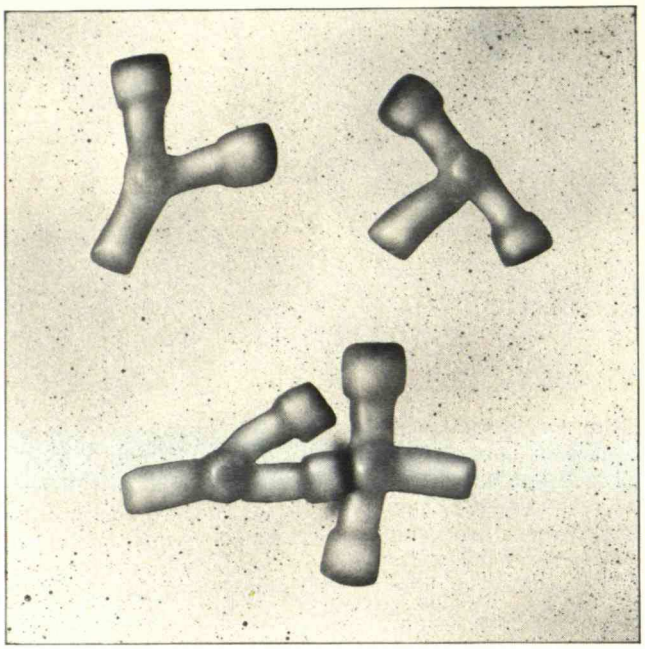
Insights into the Cause of Arthritis

Two teams of scientists working half a world apart have found a promising new clue to the cause of arthritis, the crippling ailment that results in painful swelling and stiffness in the joints of millions of people worldwide.

The teams—one at the University of Tokyo, the other at Oxford and the University of Birmingham in England—have discovered what seems to be an important abnormality in the antibodies of people who suffer from arthritis. Antibodies are produced by the body's immune system to seek out and destroy foreign substances. The antibody defect found in arthritis victims may cause the immune system to turn against itself, provoking the disorder's painful symptoms.

This discovery is especially significant since it is now becoming possible to "turn off" parts of the immune system and even eliminate specific sets of antibodies. Thus, scientists may eventually be able to treat arthritis by removing the antibodies linked with this dehabilitating condition. However, scientists have so far done only basic research on the problem, and clinical applications remain distant.

Gaining control of arthritis would be an important achievement because it is the nation's number-one crippling disease. At present, 7 million people in the United States have rheumatoid arthritis, a disorder of the tissue that lines the joints. Another 16 million people have osteoarthritis, a bone disorder.



The body's immune system recognizes a normal antibody (below, top left) as a molecule of its own. However, in arthritis victims a defect causes the antibody to bend, exposing otherwise hidden parts (top right). The immune system may see these parts as foreign (bottom), triggering the symptoms of arthritis.

Although there is as yet no true cure, some treatments can provide a measure of relief for some victims. The cost of these therapies, and the time lost from work, make arthritis very expensive: an annual bill of $25 billion in the United States alone.

Arthritis researchers have spent many years looking for abnormalities in the immune system because there is long-standing evidence of immune-system activity in many arthritic joints. Researchers first examined diseased joints for antigens, the foreign proteins that trigger the immune system's attack. Now research has shown that the immune system may actually "see" its own antibodies as antigens.

Sugar-Molecule Codes

The two scientific teams believe that a particular type of sugar molecule, called an oligosaccharide, might be responsible for the antibody abnormality in arthritis. Oligosaccharides are attached to the surface of an antibody as the final step in its manufacture within bone-marrow cells. They are considered specific to each antibody's identity, just as an address is specific to a particular household. In essence, the oligosaccharides form a code that tells who, or what, the antibody is.

Variations in antibody construction may upset the way in which the oligosaccharides are attached to the antibody. In particular, a faulty attachment of oligosaccharides can cause one kind of antibody—immunoglobulin type G—to bend as if it were hinged, perhaps exposing parts of the molecule that are normally hidden. A patient's immune system may "see" these parts as foreign invaders, triggering a response that produces the symptoms of arthritis.

During painstaking research, the scientists looked for abnormalities in the molecular arrangement of the 1,400 possible oligosaccharide units from 46 immunoglobulin G samples. They found no unusual or novel sugar molecules, but they did observe interesting variations in the proportions of the different oligosaccharides.

They found unusually few oligosaccharides containing the milk sugar galactose in victims of rheumatoid arthritis and osteoarthritis. Normally, about 10 percent of antibodies lack galactose. However, in osteoarthritis sufferers about 19 percent were without it, and in people with rheumatoid arthritis about 40 percent of antibodies had no galactose. This simple difference in the numbers of galactose-carrying antibodies might account for the distinction between people with no arthritis symptoms and those who have the disease in its various forms. The number of these unusually constructed molecules seems to affect the severity and nature of the disease.

The research teams are not yet sure whether the sugar pattern seen on the abnormal antibodies is inherited or whether it is altered by an invading virus. Since viruses are known to invade living cells and insert their own genetic material into the cell's DNA, the disease might be caused in one of several ways. A virus might cause the construction of abnormal antibodies simply by contributing a new gene—one of its own, or a foreign one. Or the virus might switch on a normally inactive gene in one of the cells derived from bone marrow that are responsible for making antibodies. This last scenario resembles what scientists are now finding out about the role of oncogenes in cancer. Oncogenes, which are apparently important in the process of normal embryonic development, may be turned on at the wrong time or in the wrong place, leading to the creation of a tumor.

—Robert Cooke □

Armageddon Under the Christmas Tree

Games in which the object is to destroy enemy spacecraft were the standard fare for holiday giving last December. But at least two exceptions are worthy of note: a board game called "Nuclear War," designed to prove that no one can win, and a computer game called "Balance of Power," which dramatizes the superpowers' problem of trying to avoid nuclear destruction while building national prestige.

Douglas Malewicki invented "Nuclear War" in 1965 when he was a graduate student at Stanford University. His motivations were three-fold, much like those of the producers of the movie *Dr. Strangelove*, which was a hit at about the same time: he wanted to make some money, have some fun, and convey a grim message about possible nuclear armageddon.

The object of "Nuclear War," which is played by groups of two to six people, is world domination. The players draw cards representing assets in their progress—atomic warheads, delivery systems, and propaganda coups, for example. "Population certificates," in various million-person denominations, are the playing chips. Players who seek to win by guile use their propaganda cards to co-opt an enemy's population. A nuclear attack requires playing a delivery card, such as an Atlas missile, in conjuction with a weapons card, such as a thermonuclear weapon; having played these cards, the attacker spins a roulette wheel to determine the number of fatalities—that is, population certificates—his opponents must give up. The carnage can vary from no casualties for a "dud" weapon to destruction of the entire solar system when a 100-megaton bomb explodes a nuclear stockpile.

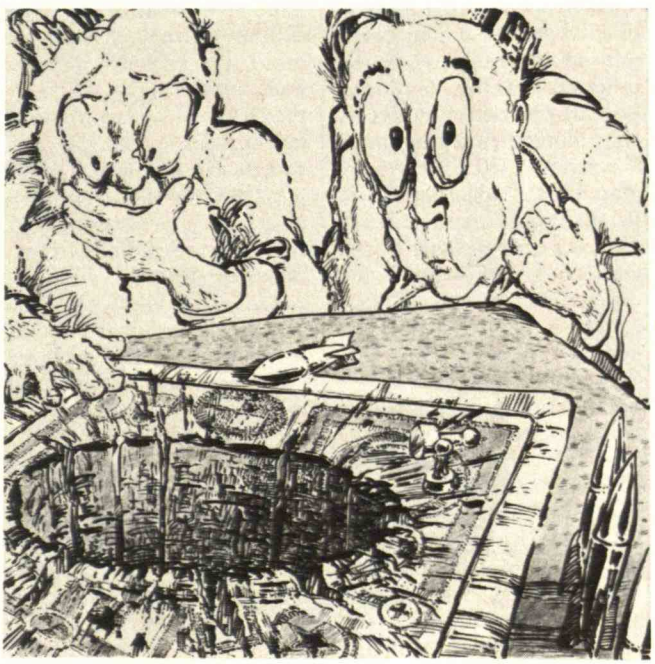
Malewicki designed his game so that it is almost impossible for any player to win. Occasionally last survivors can claim a dubious sort of victory, but a more typical outcome of "Nuclear War" is mutual suicide.

Malewicki first published the game himself. When his edition of 3,000 was sold out, he let production lapse; he had made his modest profit, and he had other fish to fry—engineering projects such as the space shuttle.

But while Malewicki considered his game defunct, it was developing something of a cult following among hardcore gamers. Hence, in 1972 Rick Loomis, the president of Flying Buffalo, Inc., a small games publisher, arranged to reissue "Nuclear War" under a royalty agreement with Malewicki. The game turned out to have a small but steady market until the 1980s, when heightened concerns over nuclear policy have substantially increased sales. Accumulated sales are now over 100,000. The game's popularity and realistic scenarios led Flying Buffalo to conduct annual nationwide computer-mail "Nuclear War" tournaments, in one of which the world was annihilated after 23 hours of play. A companion game, "Nuclear Escalation," which features MX missiles and star-wars weapons, is also selling well.

So is "Balance of Power," a new computer game in which two players assume the roles of the president of the United States and the general secretary of the Soviet Union for a simulated eight-year period. Each player's objective is to enhance his or her country's prestige while avoiding nuclear war. Players can support friendly governments, move against unfriendly governments, and try to foil whatever strategies the opposing superpower adopts. The possibilities include insurgency, coup d'états, arms shipments, military intervention, economic aid, intelligence, counterintelligence, and diplomacy.

Sixty-two natons are simulated in "Balance of Power," and players learn about each country's history, political stability, GNP, literacy rate, and economic and financial relationships with the others. If the players do well, the world survives, and the player with the most "prestige points" wins the game. But if the players lead the world to a crisis and missiles fly, the screen fades to black—everyone loses.



Can Games Promote War?

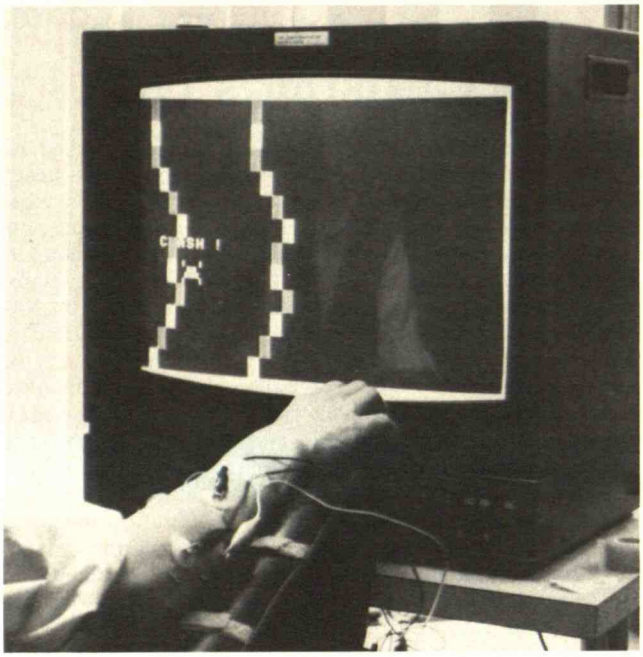
Peace groups in England recently urged a ban on "Nuclear War," condemning it as a war toy. But in fact little is known about the psychological effects of board games that portray violence. Philip Zimbardo, a Stanford University psychologist, says he knows of no directly relevant studies of war games. But Zimbardo believes that the real-life counterpart of any game is glorified or at least seems less threatening.

Loomis disagrees, at least as far as "Nuclear War" is concerned. Since the game rarely has winners, he thinks it demonstrates clearly "the folly of fighting a nuclear war." Psychologist Scott Plous of Stanford agrees with Zimbardo's cautions about the lack of scientific evidence. But he doesn't accept Loomis' opinion: "You don't participate in this game without the

ILLUSTRATIONS: MICHAEL YOUNG

goal of winning in some way," says Plous. . . . "I think this fosters an idea that you can somehow come out winning, or at least try to win."

John Pappas, an educational psychologist practicing in San Diego, takes a third view. The popularity of games like "Nuclear War" and "Balance of Power" is based on the thrill of risking all in a high-ante game. But Pappas thinks "players might also come to the realization that there's no win. Playing may even make you more mature and conscientious," he says. On the other hand, there is a risk, says Pappas: players may never "get to the point where they can distinguish reality from the late-late show."—*Albert Gross* □



A model demonstrates biofeedback therapy: electrical signals from nerves in the lower arm control a video car, and the task is to move the car down the highway without a crash.

Video That Makes Therapy Fun

For the last 12 of his 14 years, Peter has been disabled as the result of brain damage suffered in an accident. Until he came to New York University's Rusk Institute of Rehabilitation Medicine a few months ago, Peter's arms remained at his side except to flail almost uncontrollably. He could not pick anything up except in a clumsy fashion. He could not even feed himself.

Now Peter has been dramatically helped by a new type of biofeedback therapy. Devised by psychologist John Gianutsos, who heads Rusks' Biofeedback Laboratory, the new technique turns physical therapy into a video game.

Gianutsos' biofeedback system begins by detecting the electrical activity associated with muscle movements in a patient's body. It represents these on a video screen in a way that permits the patient to see whatever changes he or she is able to make in them.

For example, two muscles usually control a joint—one muscle contracts while the other relaxes. In Gianutsos' system, the electrical signals controlling each of these muscles are detected and then displayed on a video screen—in Peter's case, as two squares of different colors. Peter's task was to superimpose the squares, and when he did that he knew he was using his muscles correctly.

Gianutsos has also developed a computer game in which patients move a simulated car on a video display by contracting and relaxing the appropriate muscles. Contracting one muscle might move the car to the left, contracting another might move the car to the right. The patient's goal is to guide the car along a specified route.

All Gianutsos's games can be adjusted to match a patient's progress. For instance, the menu of his video ping pong asks which and how many muscles are to be trained and offers a choice of paddles—"small" for more skillful patients, "large" for those just entering therapy. Each player seeks to create the electrical signals in his or her nervous system that will return the simulated ping-pong ball to the opponent's court. The program keeps score, thus recording each patient's progress.

The same kinds of video games can help stroke victims regain the stability required for normal locomotion after they have lost sensation in a leg. Biofeedback is especially useful in such cases where muscle power is too low to achieve movement, because it displays the body's electrical—not physical—activity. During early rehabilitation many muscle movements are so small that they are imperceptible to the patient, Gianutsos explains, and patients who can't feel anything often give up. "But the video display can reward patients by showing nervous system activity and at the same time amplifying even the slightest movement, thus shaping their performance," he says.

Physical therapists are enthusiastic. Good therapists use fingers like sensors to determine which of a patient's muscles are working and how much. Gianutsos' programs have given them an additional guidepost to measure their accomplishment, says Jack Hofkosh, Rusk Institute's director of physical therapy.

The fact that the programs are entertaining, as well as physically challenging, helps make this treatment strategy highly successful. After all, a video game that calls for maneuvering a sports car along a winding road is most people's idea of fun, not therapy.—*Cheryl Platzman Weinstock* □

Tank Trouble

Underground storage tanks are ubiquitous. Every gasoline station has several, countless houses have them, and they are standard fixtures in many industries. Some contain water, but most contain gasoline, oil, or other more exotic compounds.

And perhaps as many as 100,000 of them are leaking.

When the first federal "Superfund" legislation was drafted, tanks contaminating aquifers were included among the hazards to be covered. But a sophisticated lobbying effort by such diverse

PHOTO: STANLEY WILLARD

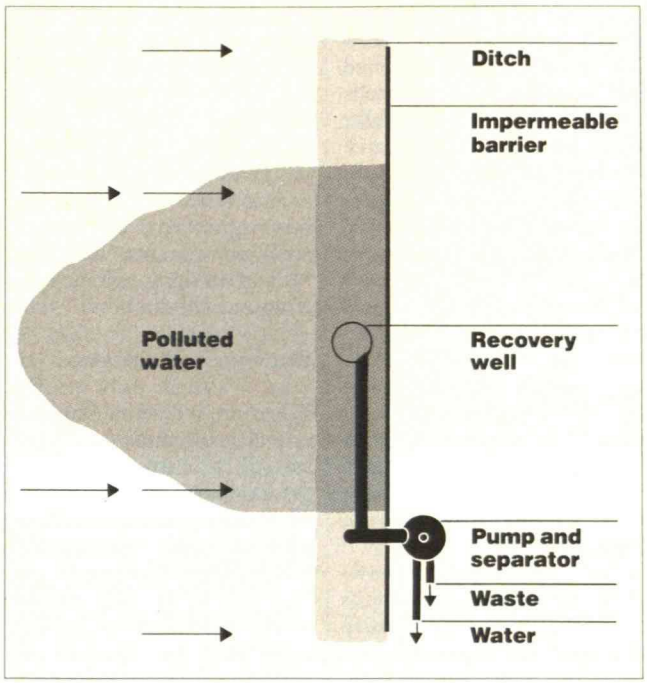
groups as petroleum product distributors, tank manufacturers, airlines, lumber yards and even beer distributors kept underground tank regulation off the Superfund agenda.

Congress has now charged the Environmental Protection Agency with regulating underground storage of petroleum and other hazardous products. As a result the EPA has framed guidelines that give state and local authorities a basis for regulating tank installation, monitoring tank safety, and, where necessary, assessing polluters for the clean-up of damaged water supplies.

Leaking underground storage tanks present a formidable challenge to any regulatory body. While toxic waste dumps are likely to be concentrated in identifiable areas, underground storage tanks are not. They may be almost anywhere, abandoned and forgotten. Contamination of water supplies has been linked to tanks beneath gas stations, factories, farms, even schools and private homes.

For example, Provincetown, Mass., has already spent more than $3 million trying to restore a water-supply aquifer polluted with gasoline from *one* leaking tank beneath a service station, and litigation may drive costs still higher.

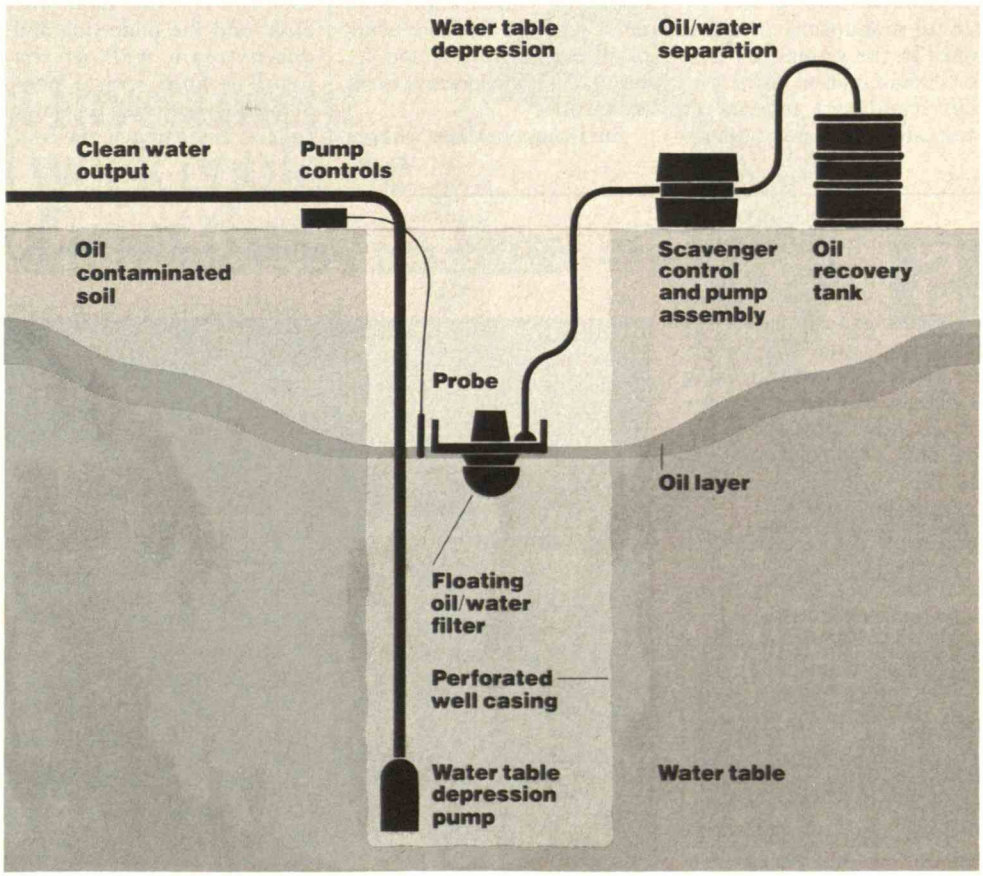
Stirred by such problems, the petroleum products industry has developed a new technology for building storage tanks. Fiberglass-reinforced "chemical-compatible" plastics are applied to protect the outside of conventional steel tanks. The use of so-called "secondary containers"—a tank-within-a-tank construction—is increasing. Indeed, new tanks of these kinds are now more



Leaking underground tanks are a major source of groundwater pollution, and cleanup is both expensive and time-consuming.

Polluted water in a near-surface aquifer can usually be collected in a trench (left) with an impermeable barrier on its downstream side. Waste and water are separated after being drawn from the trench, and the clean water is returned to the aquifer.

Pollution of a deep aquifer presents a more difficult cleanup problem, usually requiring several wells. Each well uses two pumps (below). One draws clean water from the aquifer to control its level in the well, and the other lifts the polluted water to the surface for treatment.



DIAGRAMS: OMNIGRAPHICS

the rule than the exception for the nation's two million company-owned service stations.

But this covers fewer than half the underground gasoline storage tanks nationwide. It's the smaller operators, the "mom-'n-pop" outlets, often in rural communities where underground aquifers are the primary sources of drinking water, that are now the major risks, and the federal policy favoring decentralization of all regulation has left to the states the thorny problem of managing this invisible threat.

Consider, for example, the problem confronted by authorities in Maine, more than 95 percent of whose population draw their drinking water from the ground. The state Department of Environmental Protection (DEP) asked for periodic testing, either by careful monitoring of inventories in the ground or tests for contamination of nearby soil; mandatory renewal of tanks after 20 years of use (as in neighboring New Hampshire); and secondary containers on all tanks installed within 300 feet of public wells or 1,000 feet of private wells. But lobbying by the Maine Oil Dealers Association substantially weakened this comprehensive plan when it came before the state legislature last year.

"They just went bananas on secondary containment," says the DEP's Marcel Moreau. "They called it an unproven technology that would cost small businesses too much money. Everyone would go broke and the state of Maine would become bankrupt."

What finally emerged was a measure mandating secondary containment or monitors to detect contamination on tanks in "geologically sensitive areas," registration of all tanks with the DEP, licensing of all tank installers, and access for state inspectors to all tanks.

Environmentalists charge that the legislation left Maine with a policy geared to detecting leaks, not to preventing them. Moreau is frustrated. "Basically, every steel tank is in the ground today until it leaks," he says.

And "underground water is not something we inherit from our parents," he says. "It's something we borrow from our children."

Clean-up Technologies

When the inevitable happens and groundwater is polluted, several clean-up technologies are available. When the contaminant is in an aquifer near the surface, the American Petroleum Institute favors an "interceptor trench" system to trap hydrocarbons. A trench is dug below the spreading "plume" of hydrocarbons leaking from the tank, and the underside and downstream wall of the trench is lined with a nonpermeable material. As water collects in the trench, the contaminant is skimmed off by a pump and the remaining water is injected back into the aquifer.

For deeper aquifers a dual-pump system is required. Polluted water is collected in wells dug downstream from the leak. A pump installed at the bottom of each well controls the level of the polluted water at the top of the well, and scavenger pumps draw off the floating pollutant for treatment.

Neither process is cheap or quick. Groundwater flows slowly, and clean-up may well take three to seven years. If dual pumping is required, the cost will be between $30,000 and $50,000 per well. Simply defining the extent of underground contamination may cost $250,000 even before clean-up begins. The Congressional Office of Technology Assessment puts a price tag of $100 billion on cleaning up the worst 10,000 tank-leaks nationwide.

—*Joel Millman* □

Human Factors at the Crossing

Some 7,000 automobiles collide with trains at grade crossings every year, and 650 people are killed. Yet every crossing is plainly marked, many are protected by lights and gates, and only 27,000 locomotives are now in service on U.S. railroads.

Why so many crashes?

For lack of "human factors" engineering that keeps people from making bad judgments, says psychologist H. W. Leibowitz of Pennsylvania State University.

Leibowitz notes that the one absolute method of lessening car-train crashes—building overpasses and underpasses to separate trains and cars at the 225,000 U.S.

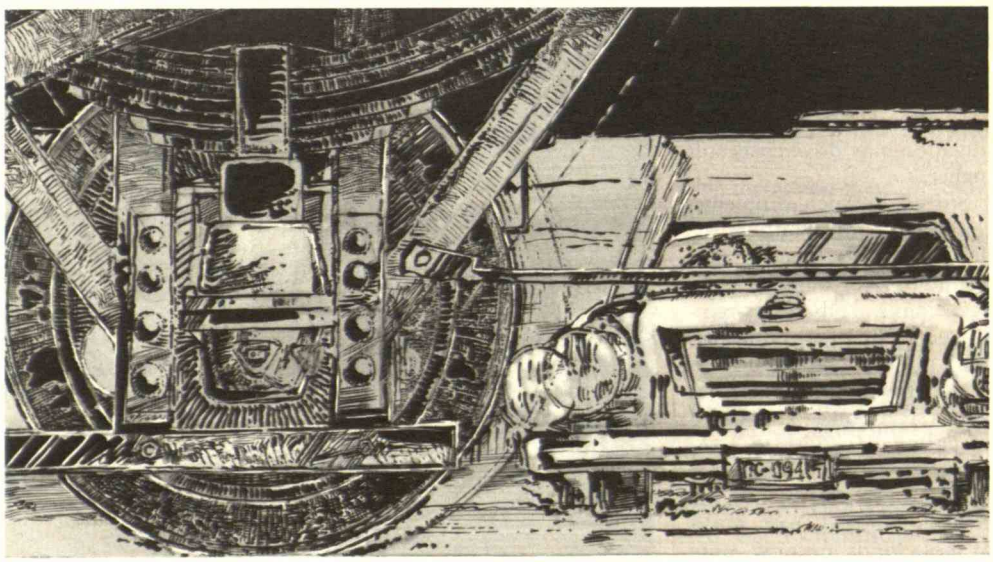


ILLUSTRATION: MICHAEL YOUNG

grade crossings—is not economically feasible. He focuses on reducing drivers' unjustified confidence in their ability to beat trains they know are coming.

Impatience and Illusions

He thinks drivers' impatience is a major problem: "We expect the automobile to save time in our daily lives, and we drive accordingly." Trains have a reputation for wasting our time—bells often sound and crossing gates drop several minutes before trains arrive, and slow trains can block crossings for frustratingly long intervals.

To explain crashes that occur when drivers can actually see the approaching train, Leibowitz cites not only impatience but three biases in human judgment:

☐ Trains are large. And the larger an object is, the more slowly it appears to be moving. This "extremely compelling" illusion, says Leibowitz, causes many a misjudgment.

☐ When we approach a grade crossing, we encounter many familiar visual cues—for example, parallel tracks that seem to converge, and uniform rows of trees or telephone poles that seem to become more and more closely spaced. These cues, which we associate with perspective, create an exaggerated sense of depth in the scene, and may make us think a train is further away than it is.

☐ When a car and a train traveling at about the same speed are on a collision course, their position relative to each other does not change much. This means that the driver does not really see the train move. As a result, he or she usually estimates its speed by watching the growth of its apparent size—assuming that if the train were traveling rapidly, its apparent size would grow rapidly. But in fact no matter how rapidly an object is traveling toward us, its apparent size grows slowly as long as we are a significant distance away, and does not begin to grow rapidly until we are very near.

All three biases work together to convince us we can win a contest that is much like Russian roulette.

What to do?

Public education to make drivers aware of these biases is one obvious suggestion, says Leibowitz. But he thinks human factors engineers could do more. For example, he asks, what about special lights or markings on locomotives to minimize illusions? He also proposes more sophisticated warning systems that ring bells and lower gates only as trains are really approaching.

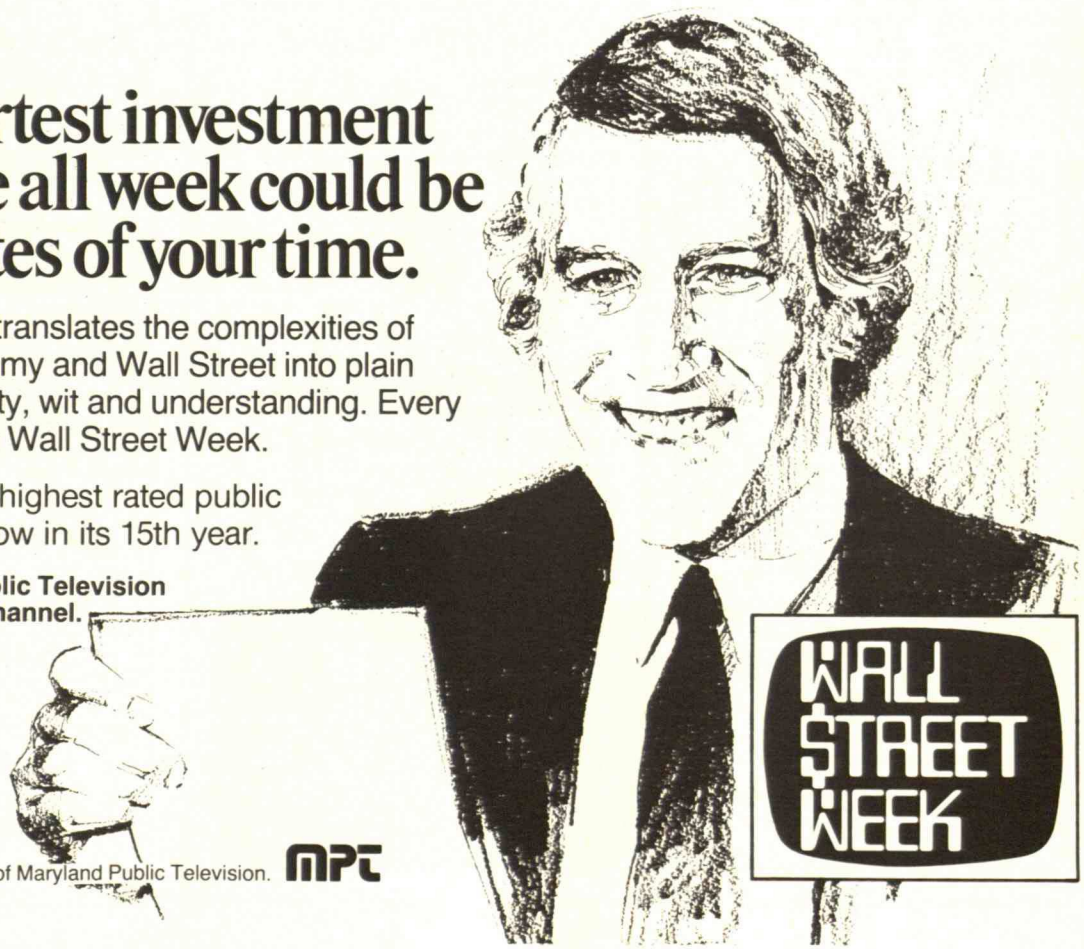
Aircraft designers pioneered human factors engineering of this sort, creating controls and instruments suited to pilots' perceptual and cognitive capabilities. The same kind of help is overdue for drivers, says Leibowitz.—*John Mattill* ☐

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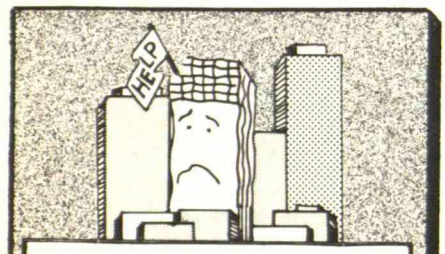
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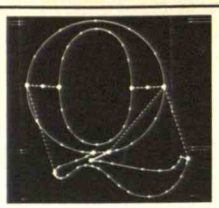
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Continued from page 31

character parts are consistent: it stores a table of parameters for the entire alphabet, such as stem widths and serif shapes. The final set of Times Roman outlines produces bitmaps at all desired resolutions and sizes.

To print text in Times Roman, the customer needs a laser printer attached to a small computer. The outlines are fed into the computer, which generates bitmaps for letters of different sizes and weights. The printer uses these bitmaps to produce the text on ordinary paper. Compugraphic has used this method for laser printers with a wide range of resolutions, and for video screens with as few as 96 dpi.

At Bitstream, which produces type libraries (but does not sell printing equipment), designers have developed a similar CAD system. They aim to establish a library of typeface outlines that yield high-quality bitmaps at a wide range of sizes and resolutions, even very low ones. Until a year ago, designers made most of the company's low-resolution bitmaps by hand. However, Matthew Carter, a designer at the company, says that Bitstream's outlines can now produce good bitmap fonts for characters with as few as 6 to 10 lines per x height—the range of most personal-computer display screens.

The Postscript program, developed by Adobe Systems in Palo Alto, goes a step further. It can store any graphic image, including type, and translate it into bitmaps at different resolutions and sizes. However, most observers agree that Postscript does not generate adequate fonts for low-resolution screens, or for printers with resolutions below 300 lpi.

Some designers remain skeptical about claims for low-resolution outline-encoding systems. At the lowest resolutions, placing each pixel requires judgment. Consequently, programs for high-quality bitmaps may come only after "years, if ever," warns Bigelow. He believes that even in the high-tech era designers will have to handcraft letterforms for the proliferating low-resolution media.

An Image in the Mind

Designers such as Hermann Zapf argue that some old metal typefaces simply will not adapt well to digital typography. In his opinion, such typefaces do not lend themselves to the "abstract and simplified bitmap of a digitized alphabet." For example, Optima, which he designed, is noted for the unusual weighting of its stems, a subtlety that does not translate well into low resolutions. "Every technology has its limitations," agrees Ted Clausen. "The challenge is to create the most legible, suitable, and beautiful letterforms for each." Digital output devices, he says, "may encourage us to design typefaces with a sturdier look, just as letterpress technology did."

However, Matthew Carter, who has designed several highly regarded typefaces, including Galliard and Snell Roundhand, believes that new technology doesn't necessarily require new designs. He argues that most typefaces will work well with any technology and points out that most of the typefaces we use today were made from those designed for hot-metal printing. A good typeface is not good just because it has adapted well to the available technology, he insists: "A reader isn't going to say, 'That's pretty good for 24 lines,' or 'That's pretty good considering the data-compaction problems.' Either it's a good face or it isn't. I'm skeptical of faces designed especially for low-resolution work."

High-resolution equipment able to display traditional typefaces will doubtless become less expensive as the cost of memory and processing power continues to fall. And a technique known as "gray scaling" may help display traditional typefaces even on relatively low-resolution screens. Instead of a bi-tonal screen on which pixels can appear only as black or white, gray scaling uses a screen on which pixels can be tuned to four or more shades of gray. Of course, gray scaling requires additional computing power, and the final effect may appear fuzzy. But by easing the transition from black to white, gray scaling appears to smooth jaggies. Paradoxically, it also suggests more detail and makes characters easier to recognize.

"At 78 dots per inch on a typical bitonal screen, you can't tell the difference between Times Roman and Souvenir," says Carter. "You can tell the difference between serif and sans serif, but that's about it." Gray scaling may make different typefaces more identifiable and may enable lower-resolution screens to imitate medium-resolution laser printers.

That would pave the way for a development known as WYSIWYG ("wizzy wig"), which stands for "What you see is what you get." With WYSIWYG the type that appears on the screen looks like the type that will be printed out. Allowing computer users to lay out text, headlines, and graphics on the screen, WYSIWYG would facilitate in-house publishing.

But even gray scaling is unlikely to produce excellent renditions of detailed typefaces. "We're in the flattery business," says Carter. "We gratify the pretensions of devices, making laser printers and screens look better than they deserve to."

Low resolutions will probably continue to challenge designers for a long time. For some the challenge is pragmatic. "We believe in making useful tools," says Mike Parker. For others the challenge is more personal and philosophic. "Low resolution forces you to throw away all the fancy aesthetic qualities," says Charles Bigelow. "It brings you down to how people perceive letters. It's an exercise in transforming texture into knowledge. Ultimately, you're designing an image in the mind of the reader." □

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A new vision of automated construction comes from Professor Alexander H. Slocum in the Department of Civil Engineering, who is beginning research on what he calls a unified construction automation design methodology (UCADM). The idea is to replace the many autonomous machines that builders are now trying to devise for different construction tasks with an integrated, automated system.

For example, when you pour a concrete slab, embed wires in it. Then a hypothesized framing machine could use one of the wires as a guide for automatically erecting studs for a wall, leaving doors at specified intervals. Next would come a drywall machine, using the framing machine's database to fasten wallboard to the newly erected frame. Finally a taping machine would use the drywall machine's database to tape the seams. □

Clamping a Lid on Homeowning

The cost of home ownership as a percentage of owners' incomes has plateaued in the 1980s at a level far above that of the 1970s—a high level that is "a serious concern for all Americans," say Professors Kermit Baker and J. James Brown of the M.I.T.-Harvard Joint Center for Housing Studies.

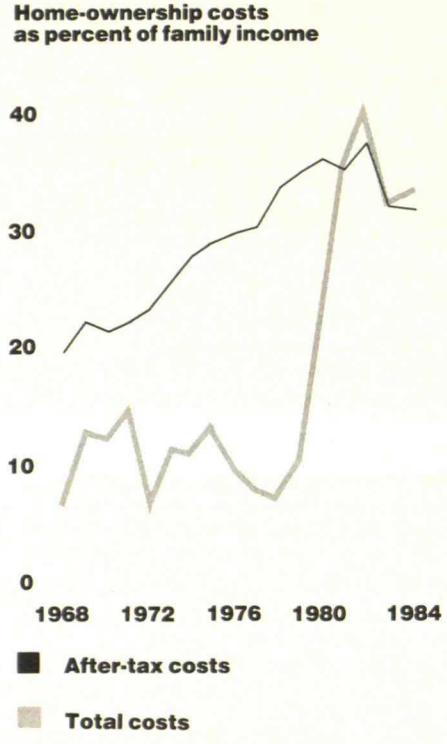
The problem is particularly acute for young households, they say, of which perhaps 800,000 in the United States have been prevented by high cost from buying homes in the last five years.

Typical homeowners now pay more than 30 percent of their annual income in home ownership costs, compared with between 10 and 15 percent between 1969 and 1979.

The median price of homes purchased in 1984 was almost $67,000, up from only $15,000 in 1968. In the same period the average income of home buyers increased by only a factor of three, from $9,000 to $28,000. Thus, say the Harvard-M.I.T. researchers, "the prices of homes purchased increased about 40 percent more than the income received by the households that bought them."

These trends concern Baker and Brown for several reasons. The high cost of homeowning has not only reduced homeownership rates for young households; it has also discouraged the formation of young independent families. Though the number of young households (the head of the family no more than 34 years old) is up by about 6 million since 1973, the number actually declined by 6 percent between 1981 and 1983, when homeownership costs were at their highest.

Furthermore, the mobility of households has also been jeopardized by the high cost of homeowning. Some 10 percent of all homeowners moved each year between 1973 and 1979; since then the number moving is down to 7 percent.—*John Mattill* □



The cost of homeowning as a percentage of owners' income skyrocketed at the start of this decade, discouraging home ownership for 800,000 young households and even discouraging the formation of such households, according to the M.I.T.-Harvard Joint Center for Housing Studies. And fully 25 percent of home purchases in 1983 and 1984, years of high ownership costs, were made possible by tax savings—the deductability of mortgage interest and property-tax payments.

Sidelining R&D

There has been a "fundamental transformation" in technological innovation in the United States since 1980, say John Friar and Mel Horwich of the Sloan School of Management: as companies see the growing importance of technology in domestic and international competition, they are spreading ever-wider nets for new technical ideas. But the corporate R&D laboratory, the traditional source of new technology, is often left on the sidelines.

Two paradigms described innovation before 1980, write Friar and Horwich in *Technology in Society*. New ideas came from individual entrepreneurs and small high-technology companies; or they came from corporate research and development. Now large and small companies are using a wide variety of managerial strategies in their search for potentially profitable innovations. These include internal entrepreneurial units, investments by captive venture-capital sections, contracts with successful external inventors, internal "think-tanks," and acquisition of firms with rights to promising innovations. None of these strategies is new, admit Friar and Horwich. What is new, they write, is the way firms have "substantially increased their use of all techniques—other than using their own R&D staffs—for technology development." □

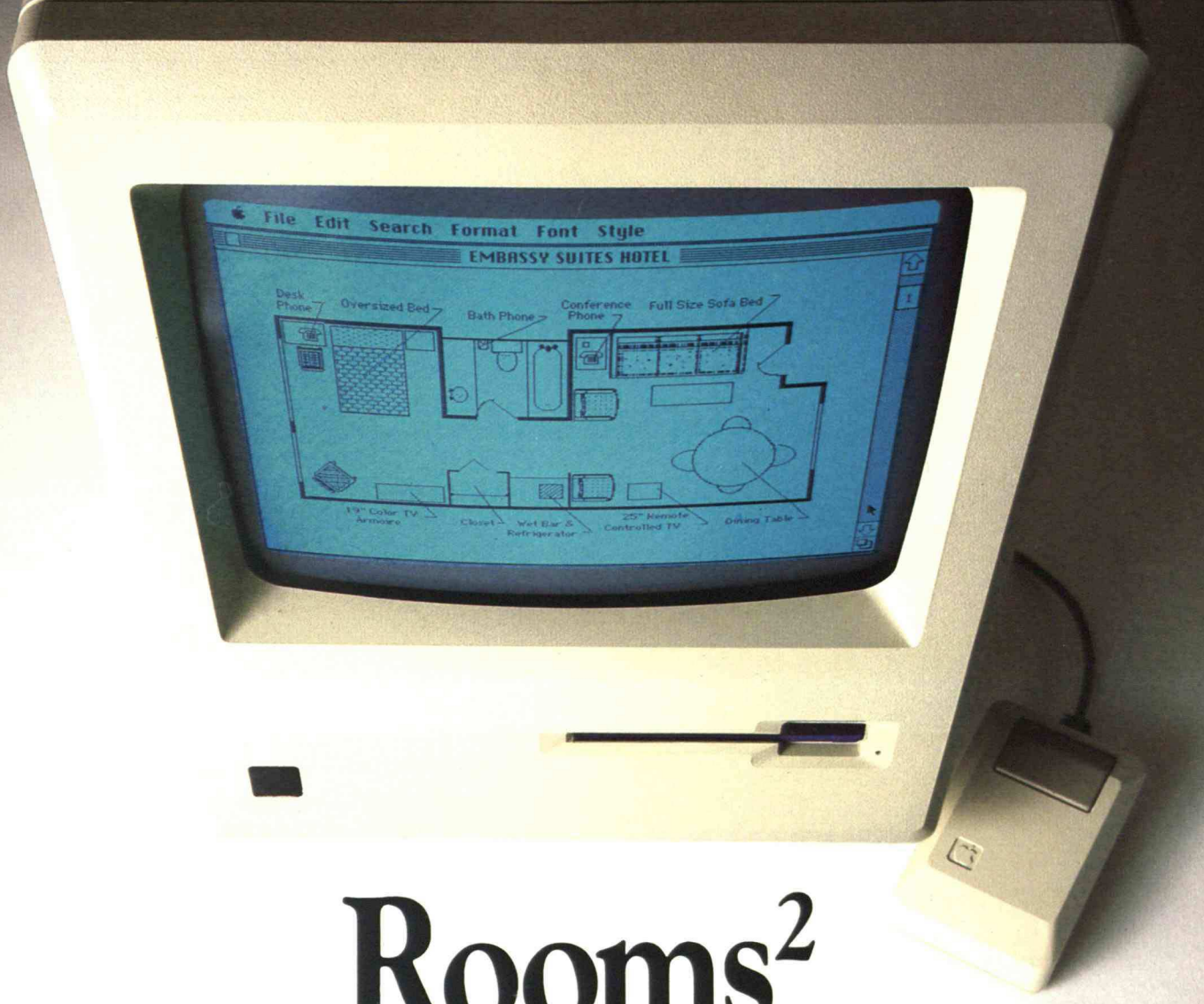
New World Auto Study

Has the world's automobile industry really returned to a steady state after the chaos of the "energy crisis"?

Not at all, says Professor Daniel Roos, director of M.I.T.'s Center for Technology, Policy, and Industrial Development. "Fundamental issues are looming just ahead." There will be new producers in the world market such as Korea and Yugoslavia, major new technologies such as ceramic engines and computerized design systems, and new relations among managers, workers, suppliers, and assemblers.

To study these changes, Roos and his colleagues are launching a new multinational research program that extends a previous world auto industry study conducted from 1981 to 1984 (*See "The Fourth Transformation in Autos," by James Womack and Daniel Jones, October 1984, p. 28.*) Funding will come from governments, producers, and foundations in the U.S. and overseas. □

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